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Movements and Habitat Use by Shovelnose and Pallid Sturgeon in the Lower Platte River, Nebraska

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MOVEMENTS AND HABITAT USE BY SHOVELNOSE AND PALLID STURGEON IN THE LOWER PLATTE RIVER, NEBRASKA

by

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MOVEMENTS AND HABITAT USE BY SHOVELNOSE AND PALLID STURGEON IN THE LOWER PLATTE RIVER, NEBRASKA

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Populations of shovelnose sturgeon *Scaphirhynchus platorynchus* and endangered pallid sturgeon *Scaphirhynchus albus* have declined since the early 1900's. A comprehensive description of habitat use and movement by shovelnose and pallid sturgeon is lacking. I used radio-telemetry to determine diel and seasonal movement and habitat use by 17 shovelnose and two wild caught pallid sturgeon in the lower Platte River, Nebraska, from July 2000 through October 2002. Shovelnose sturgeon exhibited upstream movements in April and May followed by downstream movements in June and July of 2001 and 2002. Intensive tracking during day or night 12 hour periods revealed shovelnose sturgeon moved considerably farther during the night. Pallid sturgeon were captured and released at rkm 26. Fish 621, captured May 3, 2001, entered the Missouri River on June 9th, 2001. Fish 721, caught May 23, 2002, rapidly traveled downstream, entering the Missouri River on May 30, 2002. The lower Platte River is an important migratory destination for shovelnose and pallid sturgeon with spawning by both species likely taking place between late May and early June. Depth, mean column velocity (MCV), and bottom velocity at shovelnose locations averaged 0.90 m, 60 cm/s, 35 cm/s, respectively. Pallid sturgeon used depth, MCV, and bottom velocity averaging 1.30 m,

86 cm/s, 58 cm/s, respectively. Compared with shovelnose, average MCV and bottom velocity use was significantly faster at pallid sturgeon locations. On average, depth use by shovelnose and pallid sturgeon was not significantly different. Both species were frequently located within the main channel where dune-like bottom contours persisted or in areas downstream of shallow sunken sandbars. Protection of such habitats in the lower Platte River is essential to the preservation of shovelnose and pallid sturgeon.

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General Introduction

Historically, pallid sturgeon (*Scaphirhynchus albus*) were more abundant in the main stem and major tributaries of the Missouri and Mississippi Rivers. Forbes and Richardson (1905) estimated that pallid sturgeon comprised 1 in 5 river sturgeon collected in the lower Missouri River. In the late 1970s, 1 in every 398 river sturgeon collected in the lower Missouri and middle Mississippi were pallid sturgeon (Carlson et al. 1985). Sturgeon sampling in the lower Missouri and middle Mississippi Rivers, 1996-2000, found that 1 in every 647 sturgeon collected were pallid sturgeon (Grady et al. 2001). Due to the continued decline in pallid sturgeon abundance, this species was listed as endangered in 1990 (Federal Register 55[September 6, 1990]: 36641-36647).

Although shovelnose sturgeon (*Scaphirhynchus platorynchus)* are the most abundant and widespread sturgeon in the Mississippi River drainage, numbers of this species have also declined since the early 1900's (Pflieger 1997). Shovelnose sturgeon were once found in every state in the Mississippi-Missouri-Ohio river drainage. Bailey and Cross (1954) reported catches of shovelnose sturgeon in the Rio Grande River, New Mexico, several tributaries east of the Mississippi River, and in the Ohio River eastward into Pennsylvania. Everman and Cox (1896) collected one shovelnose in the North Platte River near Casper, Wyoming and several others near Douglas, Wyoming. Today shovelnose sturgeon are depleted in Alabama, Mississippi, and South Dakota; endangered in Kentucky; rare and endangered in Oklahoma and Wyoming; rare to depleted in West Virginia; and rare in Minnesota (Miller 1972).

Management of pallid and shovelnose sturgeon populations has been hindered by a shortage of basic scientific information concerning the movement patterns and habitat requirements of these fish. Studies that have described habitat use and movement by pallid and shovelnose have generally been conducted in rivers altered by damming or channelization, such as those found in the Missouri Rivers (Latka 1994, Erickson 1992, Curtis et al. 1997). The Platte River, alternatively, has retained much more of its natural character, and offers a unique setting in which to document historical habitat use and movement. The primary objective of this study was to describe and compare movement and habitat use by shovelnose and pallid sturgeon in the lower Platte River, Nebraska. Diel movement and habitat use was examined by intensively tracking individual shovelnose and pallid sturgeon during day or night 12 hour periods. Lastly, I evaluated healing rates of shovelnose sturgeon at warm and cold water temperatures following internal transmitter implantation.

A Review of Shovelnose and Pallid Sturgeon Biology

Identification and Description – A flattened, triangular-shaped snout, an elongate body armored with bony plates, a heterocercal tail, small eyes, and a protrusable mouth, are characteristic features of shovelnose and pallid sturgeon. Characteristics that distinguish pallid sturgeon from shovelnose sturgeon include the absence of bony plates on the belly, 37 or more dorsal fin rays, 24 or more anal fin rays, and relative barbel length and placement (Pflieger 1997). Pallid sturgeon have inner barbels that are shorter than the outer two (Figure 1). The bases of the two inner barbels are in front of the bases of the outer barbels. Shovelnose sturgeon, on the other hand, have four barbels nearly equal in length, with the bases of each positioned in a row. In addition to being darker than the pallid sturgeon, shovelnose sturgeon are generally smaller than their closely related counterparts. However, coloration and size cannot consistently be relied upon to distinguish the two species (Sheehan et al. 1999).

Habitat Use – Habitat use by shovelnose sturgeon and especially pallid sturgeon is inadequately known. Both species are bottom-dwelling fish, typically preferring main channel areas of large, turbid rivers such as the Missouri or Mississippi (Kallemeyn 1983). In the Yellowstone and Missouri Rivers in Montana and North Dakota, pallid sturgeon used sandy substrates as well as greater depths more often than shovelnose sturgeon. Both species used similar current velocities (Bramblett and White 2001).

Hatchery-reared pallid sturgeon in the lower Platte River used depths from 0.33 to 1.21 m during 85% of all observations. Mean column velocities of 0.41 to 1.00 m/s and bottom velocities less than 0.70 m/s were used by pallid sturgeon at frequencies of 75%

and 91% respectively (Snook 2001). Shovelnose sturgeon in the Platte River were repeatedly located in water depths 1.5-1.8 m, mean column velocities from 0.61-0.75 m/sec and bottom velocities between 0.31-0.45 m/sec (Hofpar 1997). Both species were typically observed in areas downstream of sandbars where flows converged.

The confluences of large tributaries represent important seasonal habitat for shovelnose sturgeon (Latka 1994). During low flow in the channelized Missouri River bordering Iowa and Nebraska, shovelnose sturgeon primarily inhabited main channel areas. When flows in the Missouri River increased, shovelnose sturgeon were virtually absent from the main channel, instead inhabiting tributary mouths (Little Sioux, Platte, Nishnabotna Rivers) at greater densities (Latka 1994). Habitat use by shovelnose sturgeon in the upper Mississippi River is also dependent on river stage. During low-river stages (non-navigation) shovelnose sturgeon were usually located near the main channel or upstream of wing dams. However, throughout high river stages, shovelnose sturgeon occupied sheltered areas away from the main channel (Hurley et al. 1987).

Reproduction – Little is known about the spawning activities of shovelnose and pallid sturgeon. Reproduction by pallid sturgeon is thought to occur between April and mid-June. Male pallid sturgeon reach sexual maturity at ages 5-7 while females begin egg development at ages 9-12 and first spawned at age 15 (Keenlyne and Jenkins 1993). Shovelnose sturgeon reach sexual maturity at 5 to 7 years and are thought to spawn from late April to June at water temperatures between 16.9 and 20.5°C (Keenlyne 1997, Dryer and Sanvol 1993). Most information indicates that female pallid and shovelnose sturgeon do not spawn annually (Keenlyne and Jenkins 1993, Keenlyne 1997). Particular spawning habitats and reproductive behaviors have yet to be described for either species.

Food Habits – Pallid and shovelnose sturgeon are primarily bottom feeders. Shovelnose sturgeon are an opportunistic feeder among a wide range of aquatic macroinvertebrates, particularly larvae of the insect orders Trichoptera, Dipteral, and Ephemoptera (Modde and Schmulbach 1977). Erickson (1992) found that the diet of adult pallid sturgeon is dominated by large-river minnows and shiners (*Cyprinidae*). Carlson et al. (1985) noted aquatic invertebrates comprised most of the diet of pallid and shovelnose collected in the Missouri and Mississippi rivers, but with a greater proportion of fish in the diet of pallid sturgeon.

Causes of decline – Initially, overfishing may have adversely affected pallid sturgeon abundance in the Missouri and Mississippi River (Keenlyne 1989). Pallid sturgeon were not considered a separate species until Forbes and Richardson (1905) described pallid sturgeon from fish taken near Grafton, Illinois. Pallid sturgeon were not distinguished from shovelnose sturgeon by early commercial fishing statistics. Having been considered rare since their identification, overharvesting of river sturgeon in the early to mid-1900's undoubtedly reduced pallid sturgeon stocks.

Although shovelnose sturgeon currently inhabit nearly all sections of the Missouri and Mississippi rivers and their major tributaries, their abundance over the past 100 years has noticeably decreased (Pflieger 1997, Keenlyne 1997). Even though shovelnose sturgeon seem more resilient than pallid sturgeon, their stocks are sensitive to low levels of exploitation (Quist et. al. 2002). The recent catch of sturgeon, consisting almost entirely of shovelnose, has amounted to only about 5,000 pounds annually in Missouri's section of the Missouri River (Quist et al. 2002). This represents a small fraction of the 150,530 pounds of commercially harvested "shovelnose sturgeon" reported for the state of Missouri in statistics compiled by the U.S. Fish Commission for 1899 (Pflieger 1975).

Human-induced modification of the Missouri and Mississippi rivers for navigation, power production, and agricultural water use are also thought to be primary factors responsible for the decline of both pallid and shovelnose sturgeon (Kallemeyn 1983, Dryer and Sandvol 1993). Dams and channelization are considered to have negatively impacted pallid and shovelnose sturgeon by blocking movements to spawning or feeding areas, altering river temperatures, decreasing sediment load, and altering flow regimes (Kahehl et al. 1997, Conner and Maughan 1984). Based on their food habits, pallid sturgeon may rely on turbid conditions that historically characterized to Missouri River as part of their feeding strategy (Keenlyne 1989). Accordingly, increased water clarity caused by the impoundment of the Missouri and Mississippi Rivers, is likely involved in the decline of cyprinid species and ultimately the reduction of pallid sturgeon stocks. Damming in the Missouri has also resulted in regulated flows creating river conditions that in some areas resemble more lentic than lotic habitats. Channelization of the lower 1,170 km of the Missouri River has removed approximately 64% of water and wetland surface and shortened the river by 120 km (Whitley and Campbell 1972), ultimately reducing the natural meandering and erosion process historically found in this system.

Study Area

The study area encompassed the 162 km section of the Platte River from its confluence with the Loup River near Columbus, NE, downstream to its mouth at the Missouri River near Plattsmouth, NE (Figure 2). Major tributaries of the lower Platte River include the Elkhorn River and Salt Creek. The lower Platte River has significantly greater discharge than areas upstream from Columbus (Bentall 1991).

The lower Platte River is a broad, shallow, and braided river. One of the unique features of this river is the sandbars, which shape a variety of channels of both shallow and deep water. The predominant substrate of this riverbed is sand, with gravel and silt comprising some smaller areas. The average depth of the lower Platte River is 26 cm, with less than 10% of the river over 60 cm in depth (Peters et al. 1989). The mean annual discharge of the Platte River at Louisville, Nebraska is 202.8 m^3/s (USGS streamflow data 1954-2000). The highest mean daily peak flow on record is 4528 m^3/s. The lowest mean daily flow on record is 40 m^3/s. Discharge during 2001 at Louisville peaked on March 16, at 1124 m^3/s. Discharge during all of 2002 never exceeded 433 m^3/s.

Shovelnose sturgeon inhabit the lower Platte in numbers that effectively support a sport fishery (Holland and Peters 1994) and occasionally pallid sturgeon are reported by anglers (Daryl Feit, Nebraska Game and Parks Commission, pers comm.). Consequently, the Pallid Sturgeon Recovery Plan identifies the lower section of the study area as part of recovery priority management area 4 (Dryer and Sandvol 1993).

Chapter 1: Movement of shovelnose and pallid sturgeon in the lower Platte River, Nebraska.

Introduction

Traditional flows in the Missouri River were exemplified by rising flows in the spring and early summer followed by declining flow during the late summer and fall. Today, these seasonal fluctuations have been replaced by stable flows throughout the spring, summer, and early fall that support commercial barge traffic and regulate flooding. These changes have resulted in an unnatural flow regime with adverse consequences for native river fishes including shovelnose and pallid sturgeon. Modification of river by dams can have a variety of effects upon fish species including stimuli for migration, success of migration and spawning, survival of eggs and juveniles, and food production (Stanley and Doyle 2003, Williams and Wolman 1984)). Returning flows in the Missouri River to some degree of a more natural flow has been proposed in order to avoid further degradation of the river ecosystem. Information regarding the timing and guidance mechanisms affecting shovelnose and pallid sturgeon movement is needed to better understand the seasonal flow requirements of these fish. Documenting sturgeon movement in the Platte River, a system that more closely resembles the typical flow regime encountered by pallid and shovelnose sturgeon, will allow a better understanding of how these fish respond to changes in river conditions and flow regimes. The first objective of this study determined the movement of shovelnose and pallid sturgeon in the lower Platte River, Nebraska. In addition to looking at the timing of sturgeon movement, I also attempted highlight potential mechanisms that may influence migratory behaviors.

Methods

Fish Collection - Adult shovelnose and pallid sturgeon were captured using drifted gill nets or trotlines baited with nightcrawlers. Gill nets were made up of four panels of alternating 2.5 and 5.1 cm monofilament mesh. Gill nets were drifted with the current for a distance of approximately 250 m. Trot lines were anchored to the river bottom and fished overnight for a period not exceeding 18 hours. Trot lines were 30 m long and contained 24 alternating size 10 /0 and 12 /0 hooks. All fish captured were identified, measured, and released. Morphometric measurements of barbel and head length were also taken. Sturgeon were photographed, measured for fork length, weight, and injected with a Passive Integrated Transponder (P.I.T.) tag. Sturgeon of sufficient size were implanted with a radio transmitter.

Fish Surgery - After collection, selected sturgeon were held over a plastic tub (65 x 42 x 25-cm) while their gills were constantly irrigated with water from a 12-volt pump. A 30-mm mid-ventral incision was made to allow the insertion of a sterilized transmitter. Each transmitter was equipped with a 30-cm whip antenna that protruded from the fish's belly. A small puncture hole made with a hypodermic needle near the incision allowed protrusion of the whip antennae. Three or four monofilament nylon sutures closed the incision. Following the surgical procedure, sturgeon were observed for approximately 15 minutes in the plastic tub and then released near their original capture location.

Sturgeon received a small or large transmitter based on the weight of the particular fish. Small transmitters weighed 14.5 g, measured 42 mm long x 15 mm wide, and had a life expectancy of approximately 400 days. Large transmitters weighed 20.0 g, measured 51 mm x 15 mm, and had a battery life of approximately 625 days. All transmitters were less than 2.0% of each individual's body weight (mean = 1.69%, SD = 0.30%) (Winter 1996). Each transmitter used in this study had a unique frequency (49.021-49.841 mHz), consequently individual fish were identified by the last three digits of their frequency.

Telemetry - Radio-tagged shovelnose and pallid sturgeon were located via search efforts conducted from aircraft and airboat using a scanning receiver with a loop antenna. Aerial surveys, searched the entire study area, and located fish approximately twice per month from October of 2000 through January of 2003. Once a fish's signal was detected from the aircraft the particular coordinates were logged using a hand-held global positioning system (GPS) unit.

Fish were located from the airboat once per week from August to October, 2000, from May to December, 2001, and from March to October, 2002. Once a sturgeon was located from the airboat, the position was identified using the GPS unit. Radiolocation accuracy from the airboat was confirmed by removing the coaxial from the antennae and listening for the signal. Search efforts continued until a signal was detected with the receiver and attached cable.

To monitor sturgeon movement into or out of the Platte River, a data logging telemetry station was positioned at the Schilling Wildlife Management Area at the confluence of the Platte and Missouri Rivers. Once a radio-tagged sturgeon moved into the Missouri River, radio signals could not be detected due to the increased depth and conductivity found in the Missouri. Logging the particular date a fish moved into or out of the Platte River provided addition data points that filled gaps between successive locations.

Movement Analysis - GPS data, collected during aerial and airboat surveys (random and diel), was processed by uploading the coordinates into MapSource™ (GARMIN Corporation 1999) and then determining the straight-line distances moved between successive locations. Assessments of fish movement are minimal estimates because lateral movement was not included and movement between successive locations was undetectable. Upstream movement between consecutive locations was assigned a positive value while downstream movement was given a negative value. Total range of movement was calculated by subtracting the farthest downstream contact from a particular fish's most upstream location. Travel rates (km/d) were calculated by dividing the particular distance by the total time a fish was tracked. Total distance moved by individual sturgeon was determined by assigning all movements with a positive value. Net distance moved was calculated by subtracting downstream (-) movement from upstream (+) movement. Total and net distance moved was calculated for each month of the study. Average monthly movement was determined by dividing the total or net distance moved by all fish during each month by the number sturgeon tracked during that particular month.

$$TD_{mean} = \left| M_{up} + M_{down} \right| / \# \text{ fish tracked in a particular month}$$

Results

Twenty shovelnose sturgeon (560-693 mm fork length; 750-1,260g) and 2 pallid sturgeon (880-1,030 mm FL; 2,450-4,100g) were captured and implanted with radio transmitters during 2000–2002 (Table 1 and Figure 3). Except for the six shovelnose sturgeon that dropped transmitters, neither species was affected by the capture or transmitter implantation. Four of the six fish that dropped transmitters were implanted during July 2000 at water temperatures > 26° C and dropped their transmitters soon after their release. Four of the transmitters dropped by shovelnose sturgeon were recovered by locating the signal with the receiver and coaxial cable and sifting through the sand near that location. An additional shovelnose, fish 021/341, dropped its transmitter seven months after receiving a second transmitter. Six of the 20 radio-tagged shovelnose sturgeon were excluded from the movement analysis because they had either dropped their transmitter or had been located five or fewer times during the study. The remaining shovelnose were located a total of 363 times from the air and an additional 389 times from the boat. Each shovelnose sturgeon was contacted (air + boat) an average of 54 times (range = 24 – 111). Pallid sturgeon were contacted 3 times from the air and 17 times from the airboat. Neither pallid sturgeon carried any tags when captured and were presumed to be wild fish.

Shovelnose Sturgeon

2000 - When the final surgery of 2000 was completed on the August 24, eight shovelnose sturgeon were available to track. Fish 121 and 641 were each implanted near rkm 11 on August 17. Another shovelnose sturgeon, fish 501, was implanted and released one week later at rkm 25. All of these fish were generally sedentary from the time of capture until October 31 when each fish began traveling downstream, eventually over-wintering in the Missouri River (Figure 4). The final contact with fish 121 occurred on December 4 near rkm 3. The last contact with fish 641 occurred on October 31 near rkm 11. Fish 501 was last observed November 11, 2000 approximately 16 km downstream from its release site near rkm 9. Contact with each of these fish was reestablished during the spring of 2001.

The other five shovelnose sturgeon implanted during 2000 remained in the Platte River throughout the year (Figures 5 and 6). Fish 121, 641, and 501, failed to exhibit any notable downstream movements. From September through December of 2000 no radio-tagged fish in the Platte River moved farther than 4.8 km during a given month. Shovelnose sturgeon implanted during the latter part of 2000 traveled the greatest distance during November (mean = 3.53 km or 0.12 km/d) (Table 2). On average, each shovelnose tracked during November moved upstream 3.39 km (Table 3). Shovelnose sturgeon were stationary during December of 2000, moving only an average of 0.021 km/d.

2001 - Shovelnose sturgeon remained inactive until the spring of 2001. From April through May, 2001, four of eight radio-tagged shovelnose exhibited coordinated upstream movements averaging 107.9 km (range = 90.3 – 134.9 km) (Figure 7). A fifth shovelnose sturgeon (fish 21/341) may have traveled a significant upstream distance as well. This shovelnose began moving upstream April 9, and continued migrationing until at least April 23 when contact was lost. Seven weeks later this fish was located 30.9 km downstream from the April 23 position (Figure 8). Upstream movement by fish 121 and 641 included movement out of the Missouri River (Figure 4). Fish 101, 121, and 641 each moved to locations between Fremont and Schuyler, NE. Fish 161 moved to rkm 160, immediately below the Loup Power Canal near Columbus, NE. Upstream movement was observed during April and May of 2001 followed by coordinated downstream movements beginning the last week of June. By July 17, 2001, all of the long distance migratory fish had moved back downstream. Three of the four long distance migratory fish returned to locations within 5 km of their initial position prior to the spring movement. During the peak upstream migration fish 121 traveled 39 km in six days (5.6 km/d). Fish 161 traveled at the greatest downstream rate of 9.2 km/d from June 22 – 27. It also exhibited the greatest distance between two contact locations during any year of the study, approximately 135 km.

Although fish 081 and 201/401 moved little during 2001, these shovelnose sturgeon were also active during spring months (Figure 8). Fish 501, which migrated out of the Missouri River, was also observed traveling upstream during April and early May of 2001 (Figure 4). On average, each shovelnose sturgeon migrated upstream a respective 18.0 km and 20.6 km during the months of April and May (Table 2). Net downstream movements averaged -11.1 km and -14.0 km correspondingly during June and July (Table 3). Shovelnose were generally inactive from January to March and from August through December of 2001. During these months, movement rates never exceeded 0.183 km/day. From April through July of 2001, total movement rates per fish were never less than 0.525 km/d.

2002 – Due to the spring migratory behaviors exhibited by nearly all radio-tagged shovelnose sturgeon in 2001 we implanted new fish as early as possible in 2002. Five additional shovelnose sturgeon were fitted with transmitters from March 28 to May 3 of 2002. Tracking of another six individuals, including 3 reimplanted fish, carried over from 2001. Fish 841 dropped its transmitter shortly after its release. The transmitter carried by Fish 21/341 was dropped on May 22, 2002. Transmitters carried by fish 521, 661, and 101/111 each expired during May of 2002. Fish 821 was released at the Louisville boat ramp (rkm 26) on May 3, 2002. This shovelnose migrated 12.5 km upstream soon after its release where it became sedentary from May 20 to May 30, 2002. Five days later this fish was captured and released by the Nebraska Game and Parks Commission approximately 500 m below the mouth of the Platte River. Fish 821 traveled a total distance of 38.5 km downstream, at an average rate of 7.7 km/d. This fish reentered the Platte River for two days in mid-July and again from September 10 through September 24, 2002. However, as of July 20, 2003 this fish had not returned to the Platte River.

Movement by shovelnose sturgeon was again coordinated in 2002. All radio-tagged shovelnose sturgeon, except fish 101/111, moved upstream during late April and early May of 2002 (Figure 9). On average, each shovelnose sturgeon traveled 5.12 and 13.11 km upstream during April and May respectively. All shovelnose sturgeon, except fish 281, traveled downstream during June of 2002. In comparison, upstream movements observed during 2002 began approximately 2 weeks after such migration were observed by fish tracked in 2001. All 2002 radio-tagged fish, except fish 281, traveled downstream from June 1 to June 13. Fish tracked during 2001 generally moved downstream during late June and early July. Fish 281, which migrated 64.8 km and 49.7 km upstream during May and June of 2002 respectively, moved downstream during two successive episodes that occurred in late July (-48.4 km) and again during the later part of August (-29.1) (Figure 10). In virtually all cases, shovelnose sturgeon maintained positions within narrow stretches of river from January to March and from October through December of 2002. The greatest distance between two contact points during 2002 was 117.5 km (fish 281).

Pallid Sturgeon

Despite intensive gill-net and trot line sampling, only two pallid sturgeon were caught in the lower Platte River during 2000-2002. The first pallid sturgeon, a gravid female (880mm FL, 2.45 kg), was taken on a trot line baited with a nightcrawler. This sturgeon, fish 621, was captured, implanted and released near Louisville, Nebraska (rkm 26) on May 3, 2001. Contact three days later located this fish 0.95 km downstream of the release site (Figure 11). Although some lateral movement was observed, fish 621 remained within 0.25 km of this location from May 6 through May 24. From May 3 to May 29, fish 621 moved at an average rate of 0.15 km/d, while from May 29 to June 9, 2001 it moved an average of 1.94 km/d. This pallid sturgeon resided in the Platte River a minimum of 37 days, entering the Missouri River on June 9, 2001.

A second pallid sturgeon, fish 721, was captured on May 23, 2002 in a drifted gill net approximately 0.80 km upstream from the capture of fish 621. It was released at the Louisville boat ramp (rkm 26). Attempts to relocated fish 721 were unsuccessful until the morning of May 28 when it was contacted from the air 14.8 km downstream from its release site (Figure 12). Nine hours later a 12-hour survey was conducted on this fish (see chapter 3). Fish 721 remained near the aerial contact location until 0200 hours on May 29. Monitoring every two hours until 0800, located this pallid sturgeon 1.9 km downstream from the 0200 hours location. Fish 721 entered the Missouri River on May 30, 2002. Fish 721 was tracked in the Platte River for 8 days traveling downstream at an average rate of 3.25 km/d.

Discussion

Ranges and Timing - Shovelnose and pallid sturgeon are capable of rapid, long distance movement. Rapid upstream and downstream migrations by *S. platorynchus* in excess of 90 km were observed during each full year of the study. Shovelnose sturgeon were typically observed moving upstream during April and May followed by downstream movement during June and July (Figure 13). Fish 721, the largest radio-tagged pallid sturgeon, traveled 25.8 km downstream in 8 days. Hurley et al. (1987) noted shovelnose sturgeon in the upper Mississippi River moved up to 11.7 km/d. Moos (1978) observed that shovelnose moved up to 540 km in the lower Missouri River. Bramblett and White (2001) found that both species moved up to 15 km/d. Range of activity was from 12.4 to 331.2 km for pallid sturgeon and from 0 to 254.1 km for shovelnose sturgeon.

Movement patterns exhibited by shovelnose sturgeon were consistent with previous findings. Shovelnose sturgeon in the upper Mississippi River were commonly sedentary, with most movements occurring in May and July (Hurley et. al. 1987). They found several fish showed homing behaviors, returning to previously occupied activity centers. Quist et al. (1999) found that most shovelnose in the Kansas River moved less than 2 km from November through March.

Both pallid sturgeon were extremely active during the last week of May. Tews (1994), tracking pallid sturgeon movement in the upper Missouri and Yellowstone Rivers, documented significant migrations during April and May with little movement occurring throughout summer and winter months. Bramblett and White (2001) reported pallid and shovelnose sturgeon moved during all seasons, but they moved less during the fall and winter.

Potential Reproductive Migrations - Evidence indicates that upstream migration by shovelnose and pallid sturgeon are guided by the fish's reproductive instincts. Following the 2001 and 2002 upstream migration, radio-tagged shovelnose sturgeon became relatively motionless for 1-3 weeks (Figure 14). The sedentary stage following the long-distance migration may represent periods during which shovelnose sturgeon spawned in the Platte River. Dates associated with the sedentary period ranged from May 18 to June 13, 2001 and from May 14 to May 28, 2002. The sedentary stage corresponds with the collection of larval *Scaphirhynchus* taken near rkm 44 on May 23, 2001 and again on May 21, 2002 (Cory Reade, UNL, pers. comm.). Given this combination of evidence, I estimate shovelnose sturgeon reproduction in the Platte River takes place between late May and early June. Bramblett and White (2001) found that long-range movements by shovelnose and pallid sturgeon in the Yellowstone and Missouri Rivers in Montana and North Dakota occurred in the spring and summer and suggested that such movements may have been associated with spawning activities. Pflieger (1975) reported peak shovelnose reproduction in the upper Mississippi takes place about May 10. The capture of fish in spawning condition indicates that shovelnose spawn from late April to June, depending on latitude (Keenlyne 1997). The particular habitats associated with the potential reproductive periods are highlighted in Chapter 2.

Moos (1978) found shovelnose sturgeon spawned when water temperatures reached 18° to 19°C in the Missouri River near Vermillion, South Dakota. Water temperatures associated with the sedentary episodes ranged 17.2 to 21.6°C during 2001 and from 15.2° to 25.1°C during 2002. These temperatures encompassed the reported values for shovelnose reproduction during 2001 and 2002.

Seasonal River Use - Shovelnose sturgeon demonstrated seasonal use of the lower Platte River. Five shovelnose sturgeon migrated out of the Platte River during the fall and four of those individuals returned the following spring. Fish that migrated out of the Missouri River exhibited upstream and downstream movement patterns consistent with shovelnose that remained in the Platte River. Early studies concluded that shovelnose sturgeon swam up tributary streams to spawn (Coker 1930, Forbes and Richardson 1920). Accordingly, shovelnose sturgeon may use the lower Platte River as a destination for reproduction.

The radio-tagged pallid sturgeon used the lower Platte River on a seasonal basis. Downstream migrations observed in 2001 and 2002 by *S. albus* and *S. platorynchus*, occurred within the same time frame. Documentation of pallid x shovelnose hybrids in the Missouri River (Carlson et. al. 1985), the suspicion of such individuals in the lower Platte River (Hofpar 1997), and the parallel timing during which pallid and shovelnose downstream migrations took place, suggest that both shovelnose and pallid sturgeon migrate into the lower Platte River and may exhibit similar reproductive timing. Given this combination of evidence, the lower Platter River appears to be an important migratory destination for both shovelnose and wild pallid sturgeon. It is evident that shovelnose sturgeon spawn in the lower Platte River. Evidence of hybrids and the collection of a gravid female (fish 621) in the lower Platte River, suggests this system may also accommodate reproduction by pallid sturgeon.

Pallid Sturgeon Reproductive Timing - The capture of fish 621 in spawning condition, the frequent report of pallid sturgeon in the Platte River during April-June (relative to other months) (Daryl Feit pers. comm.), and the coordination of downstream pallid sturgeon movement in the lower Platte River, indicates *S. albus* may use the lower Platte River for spawning. Although information was gathered on only two individuals, temporal evidence from the sedentary period exhibited by the female pallid (fish 621) and the timing of the downstream migration by both fish suggests pallid sturgeon spawn in the Platte River during May. Keenlyne and Jenkins (1993) reported that spawning probably begins in March in the lower Mississippi and Atchalfalaya rivers, in late April or early May in the lower Missouri and middle Mississippi rivers, and in late May or early June in the upper Missouri River.

Alternating Reproductive Years – Most literature indicates that shovelnose sturgeon spawn every 2 to 3 years (Christenson 1975, Moos 1978). Shovelnose sturgeon that were successfully recaptured and implanted with new transmitters illustrated evidence of such behavior. Fish 201/401, which did not move upstream during the spring 2001, moved upstream 19.2 km from April 23 to May 20, 2002 (Figure 15). Conversely, fish 101/111 migrated 84.1 km during the spring of 2001, but moved only 10.1 km upstream from April 9 to June 3, 2002. Additional movements that took place following the coordinated upstream migration in late April and were likely related to high discharge on June 12, 2002 (Figure 16). The alternating pattern of long distance movement followed by little spring movement the following year supports evidence that shovelnose sturgeon alternate years of reproduction.

Keenlyne and Jenkins (1993) reported that male pallid sturgeon may not reproduce every year, and females may wait several years between spawning. The gravid pallid sturgeon collected during 2001 resided in the Platte River for 37 days but did not return in 2002. Fish 721, collected in 2002, did not return to the Platte River during the spring of 2003. Similar to the alternating migratory patterns exhibited by shovelnose sturgeon, pallid sturgeon may migrate into the Platte River on a semi-annual basis. An extensive lapse between years of reproduction represents a potentially limiting element in the recovery of the pallid sturgeon. Implanting longer-term radio transmitters into shovelnose and pallid sturgeon would further document timing between migratory behaviors. Documenting the particular sex of each sturgeon following implantation would provide valuable information regarding the age at maturity and the number of years between spawning for male and female fish.

Migratory Cues - A variety of environmental cues, including water temperature and discharge, are important guidance mechanisms of fish migrations (Leggett 1977). These variables may play significant roles in determining the timing and extent of shovelnose sturgeon movement. We found that very little movement took place when river temperatures were less than 10°C (Figure 16). Since water temperatures less than 4°C can severely affect swimming ability (Sheehan et al. 1994), spring migrations by shovelnose sturgeon are likely limited until river temperatures increase. Quist et al. (1999) found shovelnose sturgeon in the Kansas River were generally sedentary from December to March. Corresponding water temperatures never exceeded 9°C. Upstream migrations during 2001 began during the first week in April when river temperatures ranged 8.4 - 12.8°C. River temperatures prior to April 1, 2001 never exceeded 7.7°C. Upstream movements during 2002 commenced the last week in April when river temperatures ranged from 13.3 to 16.8°C. Prior to April 7, 2002 temperatures in the Platte River never exceeded 9.0°C.

Water temperature may play a direct role in determining sturgeon movement during the winter and early spring. However, increased temperatures may indirectly influence sturgeon movement by triggering increased flows via melt runoff. Previous studies have found positive relationships between discharge and sturgeon movement (Hofpar 1997, Bramblett and White 2001). Shovelnose and pallid sturgeon have been observed with mature gametes during periods coinciding with high river flow levels; possibly indicating that onset of spawning is initiated by typical spring flooding of rivers (Mayden and Kuhajda 1997).

Evidence that supported the influence of discharge on upstream movement was apparent for shovelnose sturgeon during 2001. Discharge in the lower Platte River peaked on March 16 (1124 m3/s), April 13 (594 m3/s), April 25 (625 m3/s) and again on May 7 (906 m3/s) (Figure 17). Two weeks after the initial surge of water, most shovelnose traveled upstream including three fish that migrated out of the Missouri River. Fish continued moving well past May 7, becoming sedentary (May 18 – June 13) as flows tapered off. Initiation of upstream movement during 2002 did not appear to be directed by increased stream flows. However, other movements during other times were likely related to increased flows. For example, fish 281 migrated 35.1 km from June 11-17. Shovelnose 201/401 migrated 27.6 km from June 13-17. Fish 241 and 301 each traveled 14.5 and 12.4 km downstream respectively, from June 10-13. These movements corresponded to flows of 427 m^3/s on June 12, 2002.

Significant movement by shovelnose sturgeon from August 20-23, 2002 was likely triggered by increased flows (Figure 18). On average, each shovelnose sturgeon traveled 19.5 km during the month of August of 2002. In comparison, average movement by shovelnose sturgeon tracked during August of 2001 was only 2.65 km per fish. The vast majority of movement corresponded to increased flows in late August. Fish 241 and 301, for example, moved a total of 25.9 and 20.6 km respectively from August 13-27. Fish 381 moved downstream 18.0 km from August 22-27. Due to the large variability in annual discharge no statistical correlation between discharge and movement existed. Although it is evident that sudden increases in discharge trigger shovelnose sturgeon movement, it appears that this variable is not the sole determinant initiating spring migrations.

Movement Patterns and Management Implications – Damming of rivers alters a number of aquatic variables including water temperature and flow regime (Williams and Wolman 1984). In the relatively undisturbed lower Platte River, these variables represent mechanisms that may influence sturgeon movement. Although peak sturgeon movement during 2001 coincided with high river levels, results from 2002 were inconclusive. However, it is evident that movement by shovelnose sturgeon to is influenced by increased flow during other seasons. The role of flow fluctuation during non-reproductive season is unknown but surely such events contribute to the overall fitness of pallid and shovelnose sturgeon. With regard to sturgeon management, further investigation of the mechanisms affecting the timing of sturgeon movement, especially associated with reproduction, is needed.

Chapter 2: Habitat Use by Shovelnose and Pallid Sturgeon in the lower Platte River, Nebraska.

Introduction

Coker (1930) stated that shovelnose sturgeon were once so common that they were considered a nuisance to commercial fisherman and were destroyed when captured. Today, all species of river sturgeon are much less abundant in the main stem and major tributaries of the Missouri and Mississippi Rivers (Keenlyne 1997, Pflieger 1997). Destruction of suitable sturgeon habitat caused by damming and channelization are major factors contributing to this decline (Keenlyne 1989). Accordingly, the identification of sturgeon habitat use and habitats associated with spawning are primary research objectives listed in the recovery plan for pallid sturgeon (Dryer and Sandvol 1993). Following the listing of the pallid sturgeon as an endangered species in 1990, habitat use by shovelnose and pallid sturgeon has been described by several authors in the Missouri and Mississippi Rivers (Erickson 1992, Latka 1994, Tews 1994, Bramblett 1996, Curtis et al. 1997, Hurley 1998). These studies describe habitat use in rivers impacted by human modification and are unable to document habitat use prior to damming or channelization. These studies may document sturgeon using areas characterized as the best of what is available in a modified river.

Relative to the Missouri and Mississippi Rivers, the lower Platte River is considerably less modified. The lower Platte River is free of channelization and there are no mainstem dams. Describing habitat use by sturgeon in a more natural setting can identify habitat variables not observed in the modified rivers. Documenting habitat use and habitats associated with spawning activities will aid in the recovery of the pallid sturgeon and provide management information needed to prevent further declines in stocks of shovelnose sturgeon. My second objective of the study was to determine habitat use by shovelnose and pallid sturgeon in the lower Platte River, Nebraska. In this chapter I also highlight potential habitats associated with shovelnose reproduction.

Methods

Fish Collection - Adult shovelnose and pallid sturgeon were captured using drifted gill nets or trotlines baited with nightcrawlers. Gill nets were made up of four panels of alternating 2.5 and 5.1 cm monofilament mesh. Gill nets were drifted with the current for a distance of approximately 250 m. Trot lines were anchored to the river bottom and fished overnight for a period not exceeding 18 hours. Trot lines were 30 m long and contained 24 alternating size 10 /0 and 12 /0 hooks. All fish captured were identified, measured, and released. Morphometric measurements of barbel and head length were also taken. Sturgeon were photographed, measured for fork length, weight, and injected with a Passive Integrated Transponder (P.I.T.) tag. Sturgeon of sufficient size were implanted with a radio transmitter.

Fish Surgery - After collection, selected sturgeon were held over a plastic tub (65 x 42 x 25-cm) while their gills were constantly irrigated with water from a 12-volt pump. A 30-mm mid-ventral incision was made to allow the insertion of a sterilized transmitter. Each transmitter was equipped with a 30-cm whip antenna that protruded from the fish's belly. A small puncture hole made with a hypodermic needle near the incision allowed protrusion of the whip antennae. Three or four monofilament nylon sutures closed the incision. Following the surgical procedure, sturgeon were observed for approximately 15 minutes in the plastic tub and then released near their original capture location.

Sturgeon received a small or large transmitter based on the weight of the particular fish. Small transmitters weighed 14.5 g, measured 42 mm long x 15 mm wide, and had a life expectancy of approximately 400 days. Large transmitters weighed 20.0 g, measured 51 mm x 15 mm, and had a battery life of approximately 625 days. All transmitters were less than 2.0% of each individual's body weight (mean = 1.69%, SD = 0.30%) (Winter 1996). Each transmitter used in this study had a unique frequency (49.021-49.841 mHz), consequently individual fish were identified by the last three digits of their frequency.

Telemetry - Radio-tagged shovelnose and pallid sturgeon were located via search efforts conducted from aircraft and airboat using a scanning receiver with a loop antenna. Aerial surveys, searched the entire study area, and located fish approximately twice per month from October of 2000 through January of 2003. Once a fish's signal was detected from the aircraft the particular coordinates were logged using a hand-held global positioning system (GPS) unit.

Fish were located from the airboat once per week from August to October, 2000, from May to December, 2001, and from March to October, 2002. Once a sturgeon was located from the airboat, the position was identified using the GPS unit. Radiolocation accuracy from the airboat was confirmed by removing the coaxial from the antennae and listening for the signal. Search efforts continued until a signal was detected with the receiver and attached cable.

To monitor sturgeon movement into or out of the Platte River, a data logging telemetry station was positioned at the Schilling Wildlife Management Area at the confluence of the Platte and Missouri Rivers. Once a radio-tagged sturgeon moved into the Missouri River, radio signals could not be detected due to the increased depth and conductivity found in the Missouri. Logging the particular date a fish moved into or out of the Platte River provided addition data points that filled gaps between successive locations.

Habitat Use - Habitats used by shovelnose and pallid sturgeon were determined once a particular fish was located during the airboat surveys. Physical habitat measures included water depth (m), mean column velocity (cm/s), bottom velocity (cm/s), substrate composition, and instream or out of stream cover. These variables were measured at the sturgeon's central location and four other positions located 2 m upstream, 2 m downstream, 2 m to the left, and 2 m to the right of the central location (Figure 19). Single measurements of water temperature (°C), conductivity ($\mu S/cm^2$), specific conductivity ($\mu S/ cm^2$), total suspended solids (mg/L), and dissolved oxygen (mg/L) were taken immediately near the fish's central location. Distance (m) to the nearest shoreline or sandbar was determined using a laser range finder. A digital photograph and a detailed drawing of the area surrounding the sturgeon's location was also taken for macro-habitat use interpretation and future reference. Beginning in 2001 the presence or absence of underwater sand dunes was also noted.

Water depth was measured to the nearest 1.5 cm using a 1.83 m top setting wading rod. The mean column velocity was measured at 0.6 x depth while bottom velocities were measured approximately 12 cm from the river bottom. Visually examining a handful of substrate or probing the bottom using a wading rod determined substrate composition. Substrate type was classified by estimating the particular percentage of silt (<0.2 mm), sand (0.2-2.0 mm), and gravel (2.0-4.0 mm) at each of the five locations.

Habitat Use Analysis - In this study, habitat use data were collected on individual shovelnose and pallid sturgeon. Weekly fish locations combined with one randomly chosen diel data point were considered independent measurements. Because data collected during diel sampling sessions was measured over a relatively short time period, this data was not deemed independent and therefore not included in the overall analysis of habitat use. Data gathered during the diel sampling periods was used solely to contrast day versus night habitat use.

Measures of depth use, mean column velocity use, and bottom velocity use by shovelnose and pallid sturgeon were evaluated using analysis of variance (ANOVA) procedures. Data analysis was carried out using the Statistical Analysis System (SAS) to test the following hypotheses:

1) depths, mean column velocities, and bottom velocities used by shovelnose sturgeon sturgeon were not significantly different among individual fish within a year, among years, or among dates within a particular year;

2) depths, mean column velocities, and bottom velocities used by shovelnose and pallid sturgeon were not significantly different.

Following Snook (2001), habitat variables measured at the fours points surrounding each shovelnose or pallid sturgeon were compared using a pairwise t-test and critical values of least significant differences (Fisher's LSD). A rejection probability level of 0.05 was used throughout the analysis of habitat use.

Results and Discussion

To determine habitat use, 17 shovelnose sturgeon were located a total of 400 times from airboat surveys conducted during 2000-2002. Of these 383 locations were weekly observations and an additional 17 locations were randomly selected from the 12-hour surveys. Habitat use was documented from July 20 to October 31 in 2000, from May 17 to December 5 in 2001, and from March 3 to October 17 in 2002. The majority of observations (392) took place during daylight hours. Wild pallid sturgeon were located 17 times from the airboat. Fish 621, a female pallid sturgeon, was located 10 times from May 4 to June 7, 2001. Fish 721 was located 7 times during a night-time 12-hour survey conducted May 28, 2002.

Macrohabitat Use – Areas adjacent to or near shallow sunken sandbars, where secondary flows converged with the main channel, frequently held radio-tagged shovelnose and pallid sturgeon (Figure 20). A distinctive ledge, where water depth sharply increased, was always associated with the emergent or sunken sandbar complexes. When shovelnose and pallid sturgeon were located in this habitat, fish were always positioned in deeper waters adjacent to the sandbar ledge.

Habitats associated with the main channel were also used frequently by shovelnose and pallid sturgeon. Although mean column velocities within the main channel were consistently greater than 60 cm/s, negative or near-negative bottom velocity measurements were commonly associated with fish using these habitats. Such measurements corresponded to the persistence of dune-like bottom contours present during 71% of all shovelnose and pallid sturgeon relocations within the main channel

(Figure 21). Sturgeon were never observed occupying backwater areas or habitats devoid of water current. Shovelnose sturgeon were virtually never located behind traditional instream cover such as bridge pillars, logs, other woody debris, but they were found in areas with underwater sand dunes. Observation of shovelnose behind traditional instream accounted for less than 1% of all observations. Pallid sturgeon were never associated with the use of traditional instream cover but were often located using main channel areas with underwater dunes.

In rivers altered by damming and channelization, shovelnose sturgeon typically used areas along the main channel border, downstream from dams, or near wing dikes (Hurley et al. 1987, Curtis 1990). Moos (1978) generally located shovelnose sturgeon in pools below sandbars. These studies did not document the use of underwater dunes. In the Yellowstone and upper Missouri Rivers, Bramblett (1996) found that pallid sturgeon prefered sand dunes and avoided cobble and gravel. In the lower Platte River, Snook (2001) frequently observed hatchery-reared pallid sturgeon using areas downstream of sandbars where currents converge but never observed hatchery-reared pallid sturgeon within the main channel.

Water Depth – Depths used by shovelnose sturgeon ranged 0.24 to 3.20 m and averaged 0.90 m (SD = 0.44) (Figure 22). Eighty-six percent of all observations took place at depths between 0.30 and 1.30 m with only 1% of observations taking place at depths less than 0.31 m. Mean depths used by shovelnose sturgeon were neither significantly different between years ($P = 0.3990$) nor between dates within each year ($P = 0.5507$). Depth use by individual shovelnose sturgeon was significantly different ($P = 0.0432$).

Water depths used by pallid sturgeon ranged 0.58 to 2.71 m (mean = 1.29 m, SD = 0.52). Pallid sturgeon used depths between 0.61 and 1.52 m during 71% of all observations. Both pallid and shovelnose sturgeon used similar mean depths (P = 0.1834). This comparison includes data only from periods when both species were observed in the lower Platte River.

Depths used by shovelnose and pallid sturgeon were similar to previous studies conducted in the Platte River. Hofpar (1997) repeatedly found that shovelnose sturgeon used water depths from 0.61 to 0.90 m. Snook (2001) located hatchery-reared pallid sturgeon in depths between 0.33 to 1.21 m during 85% of all observations. In the Kansas River, Quist et al. (1999) located shovelnose sturgeon using depths between 1.0 and 2.0 m during 80% of all observations.

. The average depth of the lower Platte River is 26 cm, with less than 10% of the river over 60 cm in depth (Peters et al. 1989). As a result, depths used by Platte River sturgeon contrast other findings. Studies conducted on the Yellowstone and upper Missouri Rivers in Montana and North Dakota found that shovelnose sturgeon used depths ranging from 0.9 to 10.1 m, while pallid sturgeon used depths ranging from 0.6 to 14.5 m (Bramblett 1996). The range of water depths where shovelnose sturgeon were frequently located in the upper Mississippi River were 4 to 6 m deep during 1987 (Hurley et al. 1987) and 4.6 to 6.1 m during 1988 (Curtis 1997).

Water Velocity – Shovelnose sturgeon used mean column velocities ranging from 15 to 119 cm/s. Mean column velocity use averaged 60 cm/s (SD = 19) with 73% of all observations taking place between 41 and 80 cm/s (Figure 23). Less than 3% of observations documented shovelnose sturgeon using MCVs less than 30 cm/s. MCV use by shovelnose sturgeon was not significantly different among years ($P = 0.0511$). However, MCV use among dates in a year ($P = 0.0161$) and MCV use among individual shovelnose sturgeon was significantly different ($P = 0.0238$).

Mean column velocities used by pallid sturgeon ranged from 43 to 128 cm/s and averaged 86 cm/s (SD = 21). Pallid sturgeon used MCVs faster than 81 cm/s during 59% of all observations. In comparison, shovelnose sturgeon used MCVs averaging 69 cm/s during periods when radio-tagged individuals of both species were relocated in the lower Platte River. Mean column velocities used by pallid sturgeon were significantly faster ($P = 0.0093$) than velocities at shovelnose sturgeon locations.

Carlson et al. (1985) captured pallid sturgeon in areas of swifter currents compared with areas where shovelnose were collected. Pallid sturgeon in the lower Platte River used MCVs between 41 and 100 cm/s during 75% of all observations (Snook 2001). Shovelnose sturgeon tracked in the upper Mississippi River were most frequently associated with water velocities ranging from 40 to 70 cm/s at the surface (Hurley at al. 1987). Shovelnose sturgeon in the Kansas River used current velocities ranging from 1 to 111 cm/s at the surface (Quist et al. 1999). Hofpar (1997) found shovelnose in the lower Platte River most frequently used MCVs from 61 to 75 cm/s.

Bottom velocities used by shovelnose sturgeon ranged from -15 to 91 cm/s (mean = 35 cm/s, SD = 19) (Figure 24). The majority of observations (61%) in the Platte River found shovelnose sturgeon using bottom velocities between 21 and 50 cm/s. An additional 11% of observations occurred in areas where bottom velocities were less than 10 cm/s. Bottom velocity use by shovelnose sturgeon was not significantly different ($P =$

0.1349) among years, among individual fish (*P* = 0.5749), or among dates within each year (*P* = 0.4633). On average, bottom velocities at pallid sturgeon locations were significantly faster than velocities measured at shovelnose locations (*P* = 0.0202). Bottom velocities used by pallid sturgeon averaged 58 cm/s (range = 28 to 84 cm/s, SD = 16). Shovelnose sturgeon used bottom velocities averaging 41 cm/s during periods when data was collected from both species.

In the Yellowstone and upper Missouri Rivers, pallid and shovelnose sturgeon used bottom current velocities ranging from 0 to 137 cm/s and from 2 to 151 cm/s, respectively (Bramblett 1996). Bottom velocities used by shovelnose sturgeon in the Kansas River ranged from 2 to 79 cm/s. Hurley et al. (1987) consistently located shovelnose sturgeon using bottom velocities ranging from 20 to 40 cm/s. Hofpar (1997) found shovelnose sturgeon in the lower Platte River regularly used bottom velocities between 31and 45 cm/s. Snook (2001) reported hatchery-reared pallid sturgeon in the Platte River used bottom velocities less than 70 cm/s during 91% of all observation.

Variables at Surrounding Locations – In most instances, measurements of depth, mean column velocity, and bottom velocity taken at positions upstream, downstream, to the left, and to the right of each shovelnose sturgeon were not significantly different from the central location. However, some notable difference between these variables and the subsequent positions of each measurement were evident. Differences between particular positions surrounding each shovelnose sturgeon were consistent with macrohabitats where shovelnose sturgeon were frequently located.

Depths used by shovelnose sturgeon at position 1 (central location) averaged 0.90 m. Depths measured at locations upstream (# 5) and downstream (# 3) of position # 1 averaged 0.89 m and 0.88 m respectively (Figure 25) and were not significantly different from the central location. However, water depths to the left (mean 0.86 m) and right (mean 0.86 m) of the sturgeon central location were significantly shallower than positions 1, 3, and 5. Macrohabitats that held shovelnose sturgeon generally sloped shallower relative to the fish's orientation (left or right) with the sunken or emergent sandbar. This is consistent with the frequent observation of shovelnose sturgeon in areas adjacent to sunken sandbars.

Mean column velocity measured at the most downstream position (# 3) averaged 62 cm/s and was significantly faster than MCVs measured at other locations (Figure 26). MCV at the shovelnose sturgeon's central location (position 1) averaged 60 cm/s and was significantly faster than MCVs measured at position 2 (mean 58 cm/s) and 5 (mean 59 cm/s). Mean column velocities measured at locations downstream of position 5 illustrate how current velocity increased moving downstream of this position. The arrangement of velocities around the central location is consistent with the recurrent observation of shovelnose sturgeon near the downstream end of sunken sandbar complexes.

Bottom velocities measured at surrounding locations were also consistent with the frequent location of shovelnose sturgeon below sunken sandbar complexes. Bottom velocity at position 1 was not significantly different from measurements at any other location (2-5) (Figure 27). However, bottom velocity at the most downstream position (# 3) was significantly faster than bottom velocities measured at the most upstream position (# 5)

Substrate – Substrate containing sand (i.e. sand only and sand-gravel) was used extensively by shovelnose and pallid sturgeon. Shovelnose sturgeon were observed over sand-only substrates during 326 of 393 observations (83%). An additional 62 observations (15.8%) located shovelnose using a mixture of sand-gravel substrate. Only 1.3% of all observations located shovelnose using sand-silt substrate. Pallid sturgeon were always (100%) relocated over sand substrate.

Peters et al. (1989) reported that sand comprises over 80% of available substrate in the lower Platte River and also found an increase in the availability of silt and gravel during the summer. In July 2002, 45% of shovelnose observations took place over a mixture of sand and gravel substrate. However use of such substrate during other times never exceeded 18% of all observation in a particular month.

Hofpar (1997) normally documented shovelnose sturgeon in the lower Platte River over sand during most months, but found radio-tagged fish using silt substrates at higher frequencies during May and July. In the Kansas River, shovelnose sturgeon used sand substrate 92% of the time (Quist et al. 1999). Snook (2001) always located pallid sturgeon over sand substrates in the Platte River. Hurley (1998) documented pallid sturgeon over sand substrate during 88% of all observation in the middle Mississippi River.

Chemical Habitat Variables – Water temperature, dissolved oxygen, conductivity, specific conductivity, and total suspended solids were measured at shovelnose locations from July 20 to October 31, 2000, from May 17, 2001 to December 5, 2001, and from March 12 to October 17, 2002. These variables were also measured at pallid sturgeon locations from May 4 to June 7, 2001 and on May 28, 2002 (12-hour survey). Water temperature at shovelnose locations in 2000 ranged from 11.6 to 30.8°C (mean 20.3°C). In 2001, water temperatures ranged from 9.1 to 32.6°C (mean 22.3°C). Temperatures recorded at shovelnose locations during 2002 ranged from 3.2 to 31.9°C (mean 21.3°C). Water temperatures at pallid sturgeon locations in 2001 ranged from 13.2 to 24.9°C (mean 18.7°C). Shovelnose sturgeons in the Platte River were documented in water temperatures ranging from 5.9 °C in October of 1995, to 30.9 °C in July of 1996 (Hofpar 1997). Water temperatures inhabited by pallid sturgeon in the lower Platte River from May to October 1998 and from April to October, 1999, ranged from 11.4 to 33.7°C (Snook 2001).

For all years of the study, dissolved oxygen measurements at shovelnose locations ranged from 1.82 to 17.33 mg/L (mean 10.18). Dissolved oxygen measurements at pallid sturgeon locations ranged from 7.54 to 12.2 mg/L (mean 8.9) in 2001. Conductivity ranged from 80 to 1668 $\mu S/cm^2$ (mean 604) at shovelnose locations (2000-2002) and from 386 to 607$\mu S/cm^2$ (mean 488) at pallid sturgeon locations in 2001. Additional variables for each year by each particular species of sturgeon are listed in Tables 4 and 5.

Conclusions

Macrohabitat Use - Shovelnose sturgeon seldom used (< 4% of all observations) bottom velocities swifter than 71 cm/s. Negative or near negative bottom velocities at sturgeon locations were produced by flows over underwater sand dunes. Slower flows near the river bottom appear to be an important component of sturgeon habitat use. Dune contours represent areas where sturgeon gain refuge from faster flows within the main channel. Underwater dunes may also serve as areas where sturgeon actively feed given that forage items drop out or accumulate in the depressions. Because channelization accelerates water velocity and removes natural erosion and deposition processes (Whitley and Campbell 1972), this practice likely depresses bottom contour formation. Accordingly, sturgeon in channelized portions of the Mississippi and Missouri Rivers may suffer from a lack of current shelters or foraging pockets. Such shelters may become increasingly important as sturgeon attempt to migrate to spawning areas, a time when flows are significantly increased to support river navigation.

Areas downstream from shallow sunken sandbars also represent important macro-habitats for shovelnose and pallid sturgeon in the lower Platte River. Portions of the Missouri and Mississippi river that have been channelized are largely devoid of such habitats. Therefore, management practices that support the natural formation of sandbars, underwater sand dunes, or other structures that create pockets of slow bottom flows in the main channel would likely aide sturgeon recovery.

Bramblett (1996) reported that macrohabitats used by pallid sturgeon were more specific and restrictive compared with areas used by shovelnose sturgeon and the features in these macrohabitat may be more important to pallid sturgeon than to shovelnose sturgeon. Although we generally found both shovelnose and pallid sturgeon using areas below sandbars and within the main channel, pallid sturgeon were located in areas of swifter water currents. This information indicates that habitat use by shovelnose sturgeon may not exclusively represent habitats used by pallid sturgeon. Therefore, until more pallid sturgeon are radio tagged in the lower Platter River, caution should be used when designating the shovelnose sturgeon as a surrogate species.

Chemical Habitat Variables - Both species of sturgeon inhabited a wide range of water chemistry parameters and water temperatures. Chemical habitat variables recorded when both pallid and shovelnose sturgeon were located in the Platte River were similar. On average, measures of temperature ($P = 0.9892$), conductivity ($P = 0.5530$), and specific conductivity ($P = 0.4636$) were not significantly different between shovelnose and pallid sturgeon locations. Measures of dissolved oxygen at shovelnose locations were significantly greater ($P = 0.0053$) than measurements taken at pallid sturgeon locations. This trend is likely attributable to the particular timing of sturgeon relocations. Shovelnose sturgeon relocations, compared with pallid sturgeon observations, took place later in each day when dissolved oxygen levels were expectedly higher. Consequently, we would not expect that pallid or shovelnose sturgeon select particular stretches of river based exclusively on particular chemical habitat variables. The presence of sufficient water current, sandbar habitat, and underwater sand dunes appear far more important in determining habitat use by shovelnose and pallid sturgeon.

Spawning Habitats – Information describing sturgeon habitat use during spawning events is virtually non-existent. Habitat modifications in the Missouri and Mississippi River preclude the identification of such habitats used by shovelnose or pallid sturgeon. No investigator has ever reported locating the spawning beds or observed the spawning act (Kallemeyn 1983). Available information suggests shovelnose sturgeon spawn over hard substrates in primary tributary streams of main rivers (Cross 1967, Christenson 1975) or along main channel border areas of large rivers (Coker 1930, Moos 1978). Mayden and Kuhajda (1997) reported that, under natural conditions, pallid sturgeon likely spawn in fast-flowing sections of the main-stem portion of rivers.

Based on evidence from movement patterns and larval fish collection, I attempted to detail habitats associated with shovelnose sturgeon reproduction in the lower Platte River during 2001 and 2002. Throughout the spring of 2001 and 2002, radio-tagged shovelnose sturgeon migrated upstream in a coordinated fashion (Chapter 1). Following this migratory phase, shovelnose sturgeon were relatively sedentary from May 18 to June 13, 2001 and from May 14 to May 28, 2002. Water temperatures measured during the sedentary periods corresponded to previously reported ranges when shovelnose sturgeon spawn (Moos 1978). Therefore, given the coordinated fashion by which shovelnose sturgeon moved, the timing of their migration, and the water temperatures associated with the sedentary periods, I believe sedentary periods following large upstream migrations represent reproductive periods by shovelnose sturgeon. Consequently, I compared habitat use during the sedentary periods with habitat use during other times of the year.

Measures of water depth ($P = 0.0021$) and mean column velocity ($P = <0.0001$) used by migratory shovelnose sturgeon during the sedentary periods were significantly greater from depths and MVCs measured during other times of the year (Table 6). Bottom velocity use was not significantly different ($P = 0.0750$). Bottom velocity use during the sedentary period averaged 40 cm/s, while bottom velocities used by shovelnose sturgeon during all other observations averaging 35 cm/s. During the sedentary phases of 2001 and 2002, shovelnose sturgeon were located over sand or sand-gravel substrate. Shovelnose were never documented over silt substrate. Based on my observations, and assuming fish observed during the sedentary period were engaged in reproduction, shovelnose sturgeon in the lower Platte River spawn in relatively deep areas with faster flowing currents than used during non-reproductive times. Reproduction in the lower Platte River takes place over sand or sand-gravel substrate. Closer observation of habitat use during the sedentary periods that follow spring migrations can be used to observe and better document habitats associated with shovelnose reproduction.

Chapter 3: Diel movement and habitat use by shovelnose and pallid sturgeon in the lower Platte River, Nebraska.

Introduction

Shovelnose and pallid sturgeon are highly mobile, frequently making extensive migrations in river systems (Bramblett 1996). In addition, studies on shovelnose and pallid sturgeon has revealed that these fish use an array of river habitats including the main channel, main channel border, and areas behind wing dikes (Curtis et al. 1992). However, most information on sturgeon movement and habitat use is based on fish relocations that take place over extended daytime periods (Hurley 1987, Hofpar 1997, Quist et al. 1999). These studies generally document sturgeon movement on a weekly basis and habitat use only during day light hours. The third objective of my study examined movement and habitat use by shovelnose and pallid sturgeon on a short-term basis. Short term tracking will allow us to determine whether movement by shovelnose and pallid sturgeon is considered steady or burst-like. Documenting over-night habitat use by these fish may reveal the use of areas not observed during the day-time tracking activities.

Methods

Diel Movement and Habitat Use – Detailed information pertaining to the movement and habitat use throughout day and night periods was obtained by tracking a single sturgeon for 12 hours. When sturgeon locations permitted, two fish were tracked simultaneously. Tracking sessions located the fish every two hours during the 12-hour period. The observation periods occurred from 0800 to 2000 hours (day) or from 2000 to 0800 hours (night). Twelve-hour observation periods alternated between day and night based on the type preformed the previous week. One observation was randomly selected from each of the 12-hour surveys and incorporated into the random habitat use and movement data. GPS coordinates and habitat variables during the 12-hour surveys were measured in the same fashion described in Chapter 2. Given the dangerous nature of nighttime airboat travel and the associated noise, fish located away from populated sections were given higher tracking preference. Because data collected during diel sampling sessions was measured over a relatively short time period, this data was not deemed independent and therefore not included in the overall analysis of habitat use. Data gathered during the diel sampling periods was used solely to contrast day versus night habitat use. Shovelnose and pallid sturgeon observed during diel study periods were collected, implanted, and tracked according to methods described in Chapter 2.

Results

Diel Tracking Summary - During daytime (0800 – 2000 hours) observation periods, six different shovelnose sturgeon were relocated 69 times (Table 7). Two 12-hr tracking sessions occurred during August of 2000, while an additional 10 sessions occurred between May 16 and September 3, 2002. All 69 observations were used to evaluate day versus night habitat use. However, only 8 of the 12 daytime tracking sessions were used to evaluate diel movement. Four sessions were removed from the movement analysis due to incomplete fish relocation throughout the full twelve hour period. Pallid sturgeon were not observed during a day-time 12-hour tracking session.

Information concerning nighttime (2000 – 0800 hours) movement and habitat use by shovelnose and pallid sturgeon was obtained from eleven 12-hr tracking sessions (Table 8). Eight different shovelnose were observed during the nocturnal tracking periods. Two observation periods occurred during August of 2000 while an additional 9 sessions took place between May 21 and September 11, 2002. During these surveys shovelnose sturgeon were relocated a total of 76 times. All of these observations were used to determine nighttime habitat use. Nighttime movement by shovelnose sturgeon was determined only from data collected during the 2002 nocturnal observation periods. Pallid sturgeon 721 was observed during an over-night 12-hour tracking session beginning 2000 hours on May 28, 2002. Variables measured at pallid sturgeon locations were not included in the analysis of movement and habitat use by shovelnose sturgeon.

Movement – During daytime 12-hour surveys, most shovelnose sturgeon remained within an extremely small stretch of river. Fish 281, tracked on May 16, 2002, exhibited the most extensive movement during a daytime 12-hour period, traveling a total distance of 3113 m upstream. This fish moved upstream at a steady rate and was always located upstream of its previous location. Fish 241 was simultaneously tracked on May 16, 2002 however this shovelnose sturgeon was comparably motionless. Fish 241 moved only 130 m (net = 30 m upstream) during the 12-hour period and remained within the main channel from the initial to final contact.

During seven other daytime periods (not including fish 281 on May 16) shovelnose sturgeon never moved more than 425 m (mean = 178 m per fish) from the initial contact to the final contact. Excluding fish 281 (May 16), the average net distance moved by shovelnose sturgeon during the 7 other daytime 12-hour periods was -10 m (downstream). No notable difference in shovelnose movement was observed between particular 2-hour periods during the daytime sessions (Table 9).

Compared with shovelnose tracked during the day, shovelnose sturgeon observed during the overnight periods were considerably more active. Five of eight nighttime tracking sessions documented shovelnose sturgeon that moved between 425 and 9012 m. Most extensive movements were observed between midnight and 0400 hours (Table 10). Seven of eight nighttime tracking sessions found shovelnose sturgeon exhibiting wandering behaviors with frequent directional changes. Fish 281 tracked on August 5, 2002 was initially located at 1915 hours and had moved 1770 m downstream by midnight. This fish was again located 0645 hours approximately 7220 m downstream from the midnight contact. Given the distance of this fish from the base camp no 0400 hours location was made. Fish 301, tracked on June 25, 2002, moved 520 m from its initial contact on 2005 hours to the final contact at 0759 hours the following day.

Between midnight and 0204 hours this fish moved 475 m upstream. Shovelnose sturgeon tracked during the night moved an average total distance of 1610 m.

Pallid sturgeon 721 was initially contacted on May 28, 2002 at 1955 hours. This fish was then located at 0147 hours about 10 m downstream of the initial contact position. However, at 0330 hours this pallid sturgeon was located 1225 m downstream of the 0147 hours location. Locations at 0555 and 0750 hours revealed a net movement of only 20 m downstream from the contact at 0330 hours. Although consistent with the increased activity observed in shovelnose sturgeon between midnight and 0400 hours, it is unknown why this individual moved at the recorded time. Between 0147 and 0330 hours water temperature increased from 22.5 to 23.1 °C, dissolved oxygen increased from 6.16 to 7.22 mg/L, and total suspended solids decreased from 1568 to 750 mg/L. Fish 841, also tracked on May 28, 2002, moved only 60 m during the entire 12-hour period. No significant movement was observed between midnight and 0400 hours.

Habitat Use – Measures of depth ($P = 0.5939$), mean column velocity ($P = 0.3228$), and bottom velocity ($P = 0.1994$) were not significantly different between day and night observations. During the day, depth use, MCV use, and bottom velocity use averaged 0.67 m, 59 cm/s, and 36 cm/s, respectively. Depths, MCVs, and bottom velocities used during nighttime observations averaged 0.75 m, 56 cm/s, and 31 cm/s, respectively.

Fish observed during the daytime 12-hour surveys used macrohabitats consistent with fish observed during random tracking sessions. When shovelnose sturgeon were located near a sunken sandbar and its associated ledge, fish often moved upstream and downstream of the ledge but always remained in deeper water relative to the ledge location. The pallid sturgeon (721) was located in deep, fast waters of the main channel during 4 of the 7 observations. When moderate movements were detected, pallid and shovelnose sturgeon were relocated in successive areas that indicated the fish used main flows to travel upstream and downstream.

Discussion

Shovelnose sturgeon tracked during nighttime periods were considerably more active. In most cases, shovelnose sturgeon tracked during the day did not move between successive 2 hour locations. Shovelnose sturgeon tracked at night were nearly always located upstream, downstream, or adjacent to locations taking place 2 hours earlier. Although nighttime foraging peaks have been documented for other fish species (Nowal and Quinn 2002), no information is available regarding shovelnose or pallid sturgeon diel feeding behaviors. The heightened movement by shovelnose sturgeon during the night suggests that shovelnose sturgeon feed more extensively during the night.

The rate of upstream (May 16) and downstream (August 5) movement by fish 281 was consistent with the migratory rate observed during the seasonal observation of shovelnose sturgeon movement (Chapter 1). During 2001 and 2002, fish that migrated upstream did so in a steady fashion over a period of several weeks. However, downstream migrations exhibited by shovelnose sturgeon were comparable faster. For example, fish 101/111 migrated 76.9 km upstream between April 9 and May 29, 2001 but traveled downstream 68.9 km from June 13 to June 20, 2001. The steady pace at which shovelnose sturgeon were observed moving upstream may be the result of the increased energy required to battle water currents or this behavior may allow these fish to search out particular habitats, food items, or reproductive mates.

Information gathered from the diel study shows that shovelnose sturgeon are capable of both prolonged and burst-like movement. Pallid sturgeon are also able to change river positions in a short amount of time. Snook (2001) tracked hatchery-reared pallid sturgeon in the lower Platte River but found no such evidence. The most extensive movement exhibited by hatchery-reared pallid sturgeon never exceeded 225 m during a two hour period. Snook (2001) reported that pallid sturgeon were found in significantly deeper water during daytime observations (mean = 0..72 m) compared with nighttime 12-hour sessions (mean = 0.60 m). Measures of mean column and bottom velocity were not significantly different between day and night 12-hour periods.

Bramblett (1996) reported that diel activity differed between pallid and shovelnose sturgeon. The highest proportion of pallid sturgeon observed moving was during the day while the highest proportion of shovelnose sturgeon observed moving was during the night. No additional information exists regarding the diel behaviors of pallid and shovelnose sturgeon.

Chapter 4: Healing rates of shovelnose sturgeon implanted with radio-transmitters at cold and warm water temperatures.

Introduction

The use of radio-telemetry has significantly advanced the study of fish movement, habitat use, and behavior. However, a concern with biotelemetry studies, especially those that observe endangered species, is the survival of individual fish following procedures that attach radio-transmitters. Environmental stressors have been shown to intensify the adverse effects of transmitter implantation. Specifically, surgical implantation at high water temperatures has been implicated as a contributing factor to the mortality of salmonids (Bunnell et al. 1998) and other fishes (Knights and Lasee 1996, Walsh et al. 1999). Transmitter expulsion also has been documented to be directly related to water temperature (Knights and Lasee 1996). Although no clinical information regarding sturgeon mortality following transmitter implantation exists, field data suggests that increased water temperature, at the time of surgery, may reduce sturgeon survivorship as well. During 2000, four of 10 shovelnose sturgeon dropped radio-transmitters soon after the procedure. These fish were implanted at higher water temperatures than shovelnose sturgeon that retained transmitters. The fourth objective of this study examined mortality and the retention of radio-transmitters implanted into shovelnose sturgeon at warm and cold water temperatures. The information gained by observing implanted shovelnose sturgeon, documenting healing rates, survival, and transmitter retention can improve the methods used to implant endangered pallid sturgeon.

Methods

Healing Rates - Twenty-four shovelnose sturgeon were collected from the Platte River using gill nets and transported to the wet lab. Each fish was weighed (kg), measured for fork length (mm), and fitted with a unique P.I.T tag prior to transport. The last three digits of each P.I.T. were used to distinguish each individual in the text. Sixteen of the 24 shovelnose sturgeon were collected on October 1, 2002 and an additional 8 fish were collected on October 8, 2002. The original group of 16 fish were stocked in groups of four into one of four fiberglass tanks equipped either a chiller or a heater. The second group of shovelnose sturgeon were stocked in groups of two into four additional tanks also fitted with chillers or heaters. All tanks were filled with Platte River water collected near Ashland, Nebraska. Before stocking, water temperatures in each tank were adjusted to match water temperatures in the Platte River at the time of capture. Once the fish had been acclimated to the tanks for 2 days we began the gradual adjustment to the experimental temperatures of 10°C (N = 4 tanks) and 20°C (N = 4 tanks). All tanks were originally near 17.0°C, thereby requiring little adjustment to reach 20°C in four of the eight tanks. Temperature in the all tanks was adjusted at a rate of approximately 2.0°C/d.

Once water temperatures in each respective tank stabilized, fish were selected at random for transmitter implantation. Surgical procedures were preformed on October 4 and October 11, 2002. Half of the fish residing in each of the cold (N = 1 or 2) or warm (N = 1or 2) tanks were implanted with simulated transmitters in the same fashion as described previously. These fish served as the experimental animals. The remaining fish served as the control group and were not subjected to transmitter implantation. However, these fish were held up-side-down for approximately 4 minutes while their gills were irrigated with a bilge pump, just as the experimental fish. Photographs were taken immediately before surgery, immediately after surgery, 7, 17, 27, 42, and 74 days following surgery to illustrate the healing progress. A series of photographs showing abnormalities and internal transmitter placement were taken of fish that died prior to day 74. Time between successive photographs was increased due to notable fungal growth in areas where each fish had been handled. All control fish were also removed and photographed at the same intervals. Transmitters were manufactured and donated by Advanced Telemetry Systems (Isanti, MN). The weight of each transmitter ranged from 13.6 to 15.4 g and was always less than 2.0% of each fish's body weight. Each cylindrical transmitter mimicked transmitters used in the field; measuring 40 mm long with a diameter of approximately 15 mm.

Water quality was maintained by connecting each set of two holding tanks with separate biological filtration tank. Flow was generated in each tank by continuously pumping water through the filtration tank and back into the set of holding tanks. Flow direction was changed each week. Dissolved oxygen (mg/L), ammonia (ppm), nitrite (ppm), and nitrate (ppm) levels were monitored three times each week and remained within acceptable levels. Temperature was measured at least four times each week and fluctuated between 8.1 to 13.2°C (mean = 9.9) in the cold tanks and 19.8 to 22.2°C (mean = 20.3) in the warm tanks. Fish were also monitored several times each week for transmitter retention, abnormal swimming behaviors, or death.

Results

Warm Tanks – The final tissue examination was made on December 16, 2002, 74 days after the first group of shovelnose sturgeon were returned to the warm (20°C) tanks following experimental or control treatment. Only 2 shovelnose sturgeon (1 control and 1 experimental) survived throughout the entire study period. Five of 6 control fish died between October 25 and November 3, 2002. Five of 6 experimental fish died between October 24 and November 1, 2002. A single shovelnose sturgeon (#75F), implanted on October 4, dropped its radio-transmitter on October 11, 2002 as a result of two ruptured sutures. This fish did not die until October 24. Notable inflammation was present along the incision in all shovelnose sturgeon examined 7 days after transmitters were implanted. Inflammation did not worsen 17 days following surgery. Varying degrees of fungal growth, especially on the caudal peduncle and on other areas where the fish had been physically handled, was present on all experimental and control fish. Radio-tagged fish held at 20°C exhibited extensively more pectoral and caudal fin erosion compared to shovelnose sturgeon held at 10°C.

No evidence of tissue closure where the incision was made was evident in any warm water experimental fish that died prematurely. In addition to fungal growth in areas associated with handling, 50% of the experimental shovelnose sturgeon exhibited some degree of fungal growth directly over the incision. Fish 127, implanted on October 14, may have died as a direct result of the fungal infection. Very little fungal growth was found on this fish when it was examined 7 days after surgery. However, when we photographed this fish on October 31, 17 days after the surgical implantation, a 30 mm long mass of fungal matter completely covered the incision. This fish died the following day.

Documentation of healing beyond 3-weeks post surgery was limited to the single shovelnose sturgeon (#CO2) that lived throughout the study. Inflammation and tissue hemorrhaging that existed near the incision 7 days after surgery healed considerably when this fish was reexamined 10 days later. When the final examination was made on December 16 about one half of tissue separated by the scalpel's incision had reconnected the cut. The area where the antennae protruded from the fish's belly became progressively more irritated between day 7 and day 42 and never completely healed.

Cold Tanks – All experimental and control fish held in the cold tanks survived the entire 74 day experiment (Table 11). Photographs taken 7, 17, and 27 days following the surgical procedure revealed tissue inflammation comparable to fish held in the warm tanks. However, extensive healing in all six shovelnose sturgeon was noted at the conclusion of the experiment (day 74). The incision that allowed transmitter insertion had completely closed in 50% of the experimental fish by day 74. Inflammation noted on the final day was generally associated with the protruding whip antennae and not associated with the areas near the incision. Fish held in the cold tanks also exhibited fungal growth in areas where the fish were handled.

The transmitter carried by fish A16 was dropped 37 days after the surgical procedure. Fish A16 ruptured the middle of three sutures sometime before day 7 photographs were taken. When this fish was handled 10 days later a large fungal mass was present directly over the incision area. This mass was again documented on day 27 but absent when photographs were taken on November 15 (day 42). Despite the large fungal mass and transmitter expulsion this fish lived throughout the 74 day period. Final photographs revealed extensive healing near the incision. No other experimental fish held at 10°C exhibited fungal growth near the incision. Although experimental shovelnose sturgeon were euthanized at the conclusion of this experiment, this fish would have likely survived had it been returned to the Platte River. All control fish that survived the experiment were returned to the Platte River.

Discussion

Results of the tank experiment demonstrate shovelnose sturgeon implanted at cold water temperatures survive better than fish implanted at warm water temperatures. Wound healing was observed in fish held at both temperatures but more extensive incision closure was documented in shovelnose sturgeon held at 10°C. Attempts to feed shovelnose sturgeon were unsuccessful. Lack of proper nutrition may have impeded the natural healing process and contributed to mortality. However, given that both control and experimental fish held at 20°C died, surgical transmitter implantation may not be directly related to the death of these fish. I speculate warmer water was a haven for higher bacteria densities which exacerbated infection near the incision. Because 83% of all shovelnose sturgeon died between day 20 and day 31 following control and experimental procedures, the particular bacteria may have incubated for approximately 2 weeks prior to contributing to the death of the fish held at 20°C.

Notable inflammation where the whip antennae protruded was evident in shovelnose sturgeon held at both cold and warm water temperatures. This inflammation persisted throughout the entire experiment. Each external antenna was sheathed with a thin layer of Teflon which likely reduced the abrasion associated with the external transmitter. However, using a hypodermic needle which makes the smallest possible puncture hole would expectedly reduce shifting of the antenna and further reduce tissue abrasion near the protruding antenna.

Sturgeon that drop transmitters during a field telemetry study may not die as a result of the expulsion. Results from the wet-lab experiment revealed fish A16 lived 38 days after this shovelnose sturgeon dropped its transmitter. This fish, held at 10°C, was euphemized on December 16 after extensive healing was documented following the expulsion. Fish 75F, held at 20°C, survived 14 days after dropping its transmitter. Although field conditions are considerably harsher, mortality associated with transmitter expulsion in probably less than 100%.

In addition to providing better opportunity for survival, implanting shovelnose and pallid sturgeon at cold water temperatures has other benefits. We found that shovelnose and pallid sturgeon were most active from April through July (Chapter 1). Implanting fish during these times, as water temperatures steadily raise, may increase the occurrence of transmitter expulsion or fish death given the heightened movement activity during the spring and early summer. Therefore, implanting sturgeon as early as possible in a particular year not only increases fish survival but may reduce inaccuracies in movement behavior resulting from the surgical procedure. Implanting internal transmitters as early as possible would allow maximal recovery at colder water temperatures prior to spring migrations.

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Table 1. Summary of shovelnose and pallid sturgeon implanted with radio transmitters in the lower Platte River, 2000-2002.

Transmitter frequency	Species	Fork length (mm)	Weight (kg)
49.021[a]	*S. platorynchus*	598	0.82
49.021/341[b]	*S. platorynchus*	588	0.75
49.041	*S. platorynchus*	601	0.79
49.061	*S. platorynchus*	605	0.83
49.081	*S. platorynchus*	574	0.78
49.101/111[b]	*S. platorynchus*	636	0.91
49.121	*S. platorynchus*	569	0.82
49.161	*S. platorynchus*	615	0.85
49.181	*S. platorynchus*	605	0.80
49.201/401[b]	*S. platorynchus*	610	0.85
49.241	*S. platorynchus*	626	0.80
49.281	*S. platorynchus*	585	0.81
49.301	*S. platorynchus*	619	0.94
49.381	*S. platorynchus*	560	0.77
49.501	*S. platorynchus*	620	1.00
49.521	*S. platorynchus*	628	1.05
49.621	*S. albus*	880	2.45
49.641	*S. platorynchus*	693	1.25
49.661	*S. platorynchus*	642	0.97
49.721	*S. albus*	1,030	4.10
49.821	*S. platorynchus*	638	0.90
49.841	*S. platorynchus*	637	1.06

[a] The transmitter carried by this individual was dropped, recovered and later implanted into a different shovelnose.

[b] These fish were recaptured and implanted with new transmitters prior to the expiration date of the original transmitter.

Table 2. Average total movement (km/mo and (m/day)) per shovelnose sturgeon by month or day in the lower Platte River, Nebraska, 2000-2002.

Month	2000 km/month (km/day)	2001 km/month (km/day)	2002 km/month (km/day)	2000-2002 km/month (km/day)
January	-	0.36 (0.012)	2.54 (0.082)	1.45 (0.047)
February	-	0.24 (0.009)	0.63 (0.023)	0.44 (0.016)
March	-	5.66 (0.183)	0.82 (0.026)	3.24 (0.105)
April	-	21.11 (0.704)	6.22 (0.207)	13.67 (0.456)
May	-	22.91 (0.739)	16.88 (0.545)	19.90 (0.642)
June	-	17.92 (0.597)	27.65 (0.922)	22.79 (0.760)
July	-	16.28 (0.525)	3.19 (0.103)	9.74 (0.314)
August	-	2.65 (0.085)	19.51 (0.629)	8.83 (0.285)
September	1.81 (0.063)	5.22 (0.174)	8.93 (0.298)	5.32 (0.177)
October	1.11 (0.036)	2.01 (0.065)	0.97 (0.031)	1.36 (0.044)
November	3.53 (0.117)	1.4 (0.047)	0.78 (0.026)	1.90 (0.063)
December	0.66 (0.021)	1.4 (0.045)	1.02 (0.033)	1.03 (0.033)

Table 3. Average net movement (km/mo and (m/day)) per shovelnose sturgeon by month or day in the lower Platte River, Nebraska 2000-2002.

Month	**2000** km/month (km/day)	**2001** km/month (km/day)	**2002** km/month (km/day)	**2000-2002** km/month (km/day)
January	-	-0.17 (-0.005)	-2.36 (-0.076)	-1.265 (-0.041)
February	-	0.16 (0.006)	-0.6 (-0.021)	-0.22 (-0.008)
March	-	-3.90 (-0.126)	-0.26 (-0.008)	-2.08 (-0.067)
April	-	18.02 (0.601)	5.12 (0.171)	11.57 (0.386)
May	-	20.61 (0.665)	13.11 (0.423)	16.86 (0.544)
June	-	-11.07 (-0.369)	-5.33 (-0.178)	-8.2 (-0.273)
July	-	-13.98 (-0.451)	2.00 (0.065)	-5.99 (-0.193)
August	-	0.45 (0.015)	-13.49 (-0.435)	-6.52 (-0.105)
September	1.64 (0.107)	1.66 (0.055)	-1.26 (0.023)	0.68 (0.023)
October	0.79 (0.055)	1.54 (0.050)	0.98 (0.032)	1.10 (0.036)
November	-3.39 (-0.113)	-0.52 (-0.017)	0.25 (0.008)	-1.22 (-0.041)
December	-0.39 (-0.013)	-1.00 (-0.032)	0.25 (0.008)	-0.38 (-0.012)

Table 4. Summary of water chemistry data (ranges and (mean)) at shovelnose sturgeon locations in the lower Platte River, Nebraska, 2000-2002.

Year	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm^2)	Specific Conductivity (µS/cm^2)	TDS (mg/L)
2000	11.6 - 30.8 (20.3)	6.31 - 13.54 (10.72)	358 - 1668 (657)	371 - 1717 (720)	77 - 350 (149)
2001	9.1 - 32.6 (22.3)	5.26 - 15.5 (9.97)	250 - 1148 (614)	292 - 1163 (644)	46 - 922 (180)
2002	3.2 - 31.9 (21.3)	1.82 - 17.33 (10.27)	80 - 1493 (572)	101 - 1435 (609)	20 - 3040 (330)
00 - '02	3.2 32.6 (21.7)	1.82 - 17.33 (10.18)	80 - 1668 (604)	101 - 1717 (641)	20 - 3040 (182)

Table 5. Summary of water chemistry data (range and (mean)) at pallid sturgeon locations in the lower Platte River, Nebraska, 2001-2002.

Year	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm^2)	Specific Conductivity (µS/cm^2)	TDS (mg/L)
2001	13.2 - 24.9 (18.7)	7.54 - 12.2 (8.9)	386 - 607 (488)	444 - 675 (560)	198 - 1228 (646)
2002	22.0 - 25.5 (23.3)	5.81 - 8.83 (7.1)	456 - 661 (545)	476 - 654 (562)	577 - 2576 (1129)

Table 6. Habitat use variables measured during periods which shovelnose sturgeon likely spawned versus observations that occurred during other times in the lower Platte River, Nebraska. "Spawning periods" were theorized to occur during sedentary episodes following spring migrations during 2001 and 2002.

Habitat Use Period	Depth (m)	MCV (cm/s)	Bottom Velocity (cm/s)
"Spawning Period" following Spring Migration 5/18/01-6/13/01 & 5/14/02-5/28/02	**1.08**	**70**	**40**
Other Observations	**0.88**	**59**	**35**
2001 Spawning Period following Migration 5/18/01 – 6/13/01	1.18	68	43
2002 Spawning Period following Migration 5/14/02 – 5/28/02	0.92	73	35
Both Years	**1.08**	**70**	**40**
Non-spawn habitat use 2000	0.91	59	35
Non-spawn habitat use 2001	0.87	60	35
Non-spawn habitat use 2002	0.87	58	34
All Years	**0.88**	**59**	**35**

Table 7. Daytime 12-hour surveys conducted on radio-tagged shovelnose sturgeon in the lower Platte River during 2000 and 2002.

Fish	Species	Survey	Begin Date	/ Time (hrs)	End Date	/ Time (hrs)	# observations
181	*S. platorynchus*	Day	8/7/00	1115	8/7/00	1915	5
201/401	*S. platorynchus*	Day	8/14/00	1100	8/14/00	1910	5
281	*S. platorynchus*	Day	5/16/02	0810	5/16/02	1945	7
241	*S. platorynchus*	Day	5/16/02	1005	5/16/02	2000	6
201/401	*S. platorynchus*	Day	6/6/02	0820	6/6/02	1950	7
241	*S. platorynchus*	Day	6/6/02	0835	6/6/02	2000	7
281	*S. platorynchus*	Day	7/11/02	0820	7/11/02	1930	7
381	*S. platorynchus*	Day	8/1/02	0820	8/1/02	1803	6
201/401	*S. platorynchus*	Day	8/1/02	0915	8/1/02	1047	2
281	*S. platorynchus*	Day	8/20/02	1025	8/20/02	1335	3
201/401	*S. platorynchus*	Day	9/3/03	0820	9/3/03	1952	7
301	*S. platorynchus*	Day	9/3/02	0840	9/3/02	1930	7

Table 8. Nighttime 12-hour surveys conducted on radio-tagged shovelnose and pallid sturgeon in the lower Platte River during 2000 and 2002.

Fish	Species	Survey	Begin Date	/ Time (hrs)	End Date	/ Time (hrs)	# observations
181	*S. platorynchus*	Night	8/7/00	2115	8/8/00	0115	3
201/401	*S. platorynchus*	Night	8/14/00	2110	8/15/00	0500	5
201/401	*S. platorynchus*	Night	5/20/02	1945	5/21/02	0752	7
721	*S. albus*	Night	5/28/02	1955	5/29/02	0750	7
841	*S. platorynchus*	Night	5/28/02	2014	5/29/02	0800	6
281	*S. platorynchus*	Night	6/20/02	1945	6/21/02	0757	7
241	*S. platorynchus*	Night	6/25/02	1950	6/26/02	0742	7
301	*S. platorynchus*	Night	6/25/02	2005	6/26/02	0759	7
821	*S. platorynchus*	Night	7/15/02	1950	7/16/02	0730	7
281	*S. platorynchus*	Night	8/5/02	1915	8/6/02	0756	6
821	*S. platorynchus*	Night	9/10/02	1935	9/11/02	0815	7
381	*S. platorynchus*	Night	9/10/02	1940	9/11/02	0827	7

Table 9. Average total and net distances moved by radio-tagged shovelnose sturgeon in the lower Platte River during daytime 12-hour tracking periods conducted from May 16 to September 3, 2002.

Day Period	Mean Total Distance (m) moved per fish	Mean Net Distance (m) moved per fish
8am - 10am	62	48
10am - 12pm	94	87
12pm - 2pm	109	95
2pm - 4pm	118	111
4pm - 6pm	135	-13
6pm - 8pm	67	66
8am - 8pm	568	380

Table 10. Average total and net distances moved by radio-tagged shovelnose sturgeon in the lower Platte River during nighttime 12-hour tracking periods conducted from May 20 to September 11, 2002.

Night	Mean Total Distance (m) per fish	Mean Net Distance (m) per fish
8pm - 10pm	201	-183
10pm - 12am	265	-160
12am - 2am	551	-318
2am - 4am	619	-536
4am - 6am	247	-181
6am - 8am	25	12
8pm - 8am	1610	-1130

Table 11. Summary of experimental and control shovelnose sturgeon used to examine wound healing following transmitter implantation at cold (10°C) and warm (20°C) water temperatures.

Fish ID	Length(mm)	Weight (kg)	Collection Date	Treatment	Tank	Treatment Date	Death	Final Weight (kg)
423451275F[1]	625	1.00	10/1/2002	experimental	warm	10/4/2002	10/24/2002	0.86
422E0A3C02	600	0.75	10/1/2002	experimental	warm	10/4/2002	-	-
422E031404	575	0.75	10/1/2002	control	warm	10/4/2002	11/3/2002	0.67
422D7F552F	517	0.60	10/1/2002	control	warm	10/4/2002	10/29/2002	0.5
423A665835	601	0.70	10/1/2002	experimental	warm	10/4/2002	10/25/2002	0.7
4235186259	629	0.75	10/1/2002	experimental	warm	10/4/2002	10/25/2002	0.73
4234365A2D	571	0.70	10/1/2002	control	warm	10/4/2002	10/25/2002	0.65
423A4F6A28	510	0.70	10/1/2002	control	warm	10/4/2002	10/28/2002	0.7
423A525127	580	0.87	10/8/2002	experimental	warm	10/14/2002	11/1/2002	0.84
4179632575	609	0.80	10/8/2002	experimental	warm	10/14/2002	10/26/2002	0.79
423A672374	568	0.65	10/8/2002	control	warm	10/14/2002	-	-
422E103E6A	602	0.85	10/8/2002	control	warm	10/14/2002	10/24/2002	0.79
423B2D3028	683	1.1	10/1/2002	experimental	cold	10/4/2002	-	-
423A71A16[2]	612	0.8	10/1/2002	experimental	cold	10/4/2002	-	-
423A645220	587	0.75	10/1/2002	control	cold	10/4/2002	-	-
42377B2D19	573	0.7	10/1/2002	control	cold	10/4/2002	-	-
4234610D55	638	1.00	10/1/2002	experimental	cold	10/4/2002	-	-
422E080353	653	1.20	10/1/2002	experimental	cold	10/4/2002	-	-
423B5F1175	569	0.75	10/1/2002	control	cold	10/4/2002	-	-
42343E4658	558	0.75	10/1/2002	control	cold	10/4/2002	-	-
422E061F4D	610	0.95	10/8/2002	experimental	cold	10/14/2002	-	-
42343F230F	554	0.65	10/8/2002	experimental	cold	10/14/2002	-	-
422E052626	578	0.70	10/8/2002	control	cold	10/14/2002	-	-
4234387D1F	543	0.60	10/8/2002	control	cold	10/14/2002	-	-

[1] Transmitter dropped on 10/11/2002.
[2] Transmitter dropped November 8, 2002

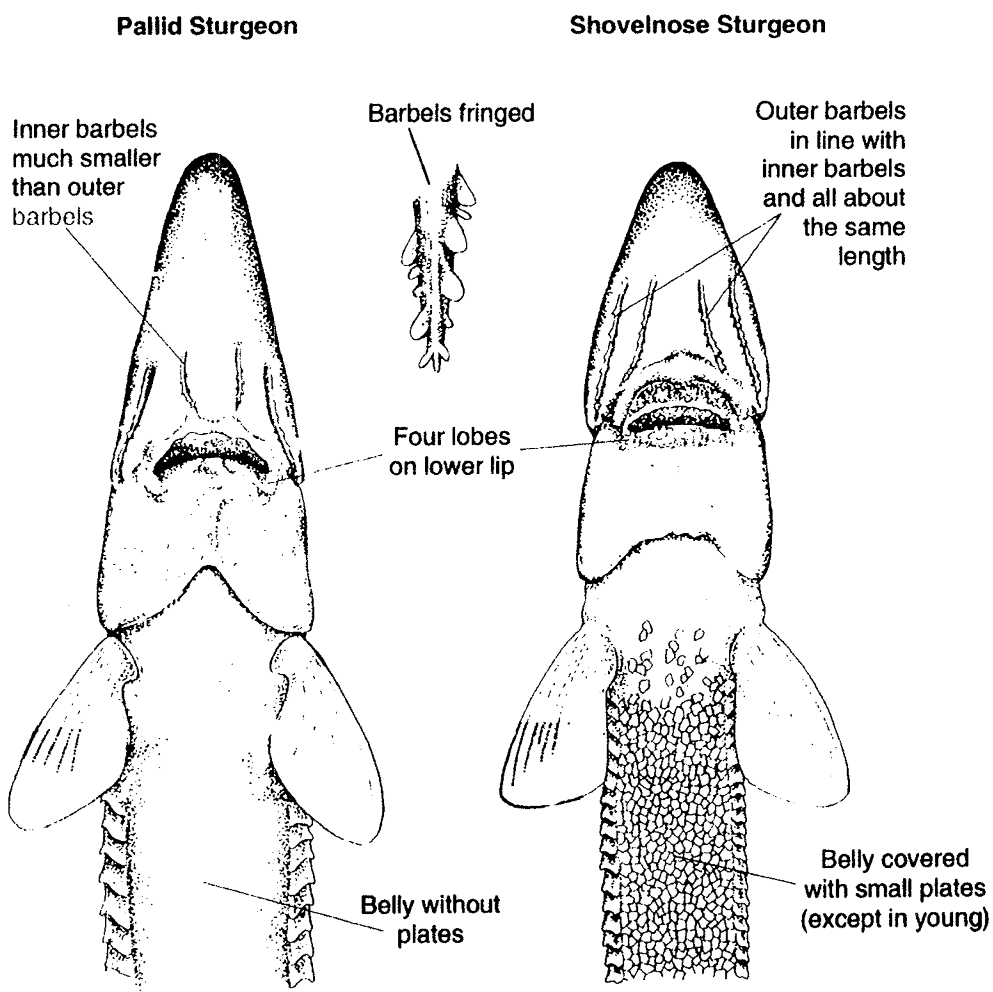

Figure 1. Characteristics that differentiate pallid and shovelnose sturgeon.

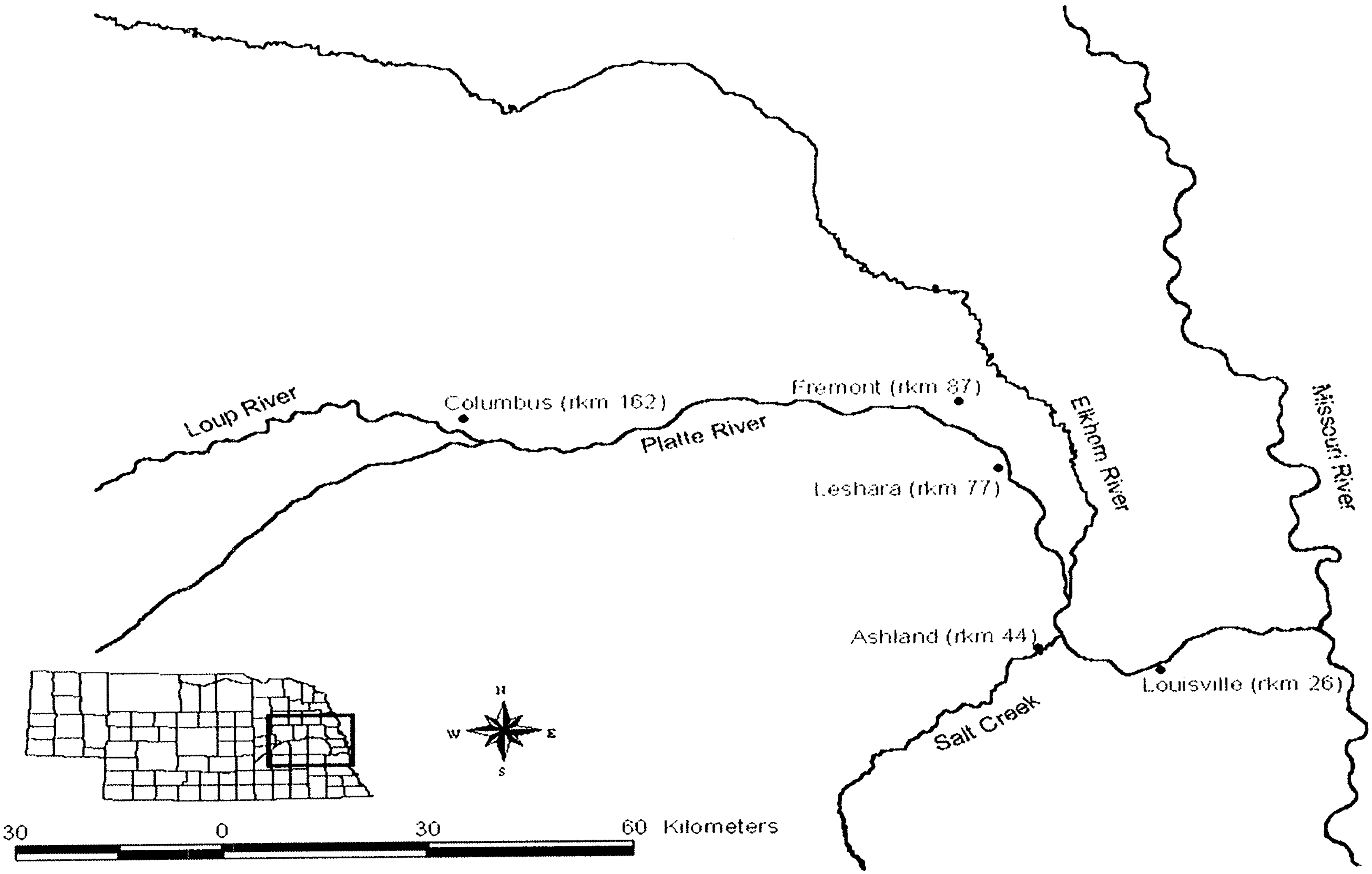

Figure 2. Map of the study area.

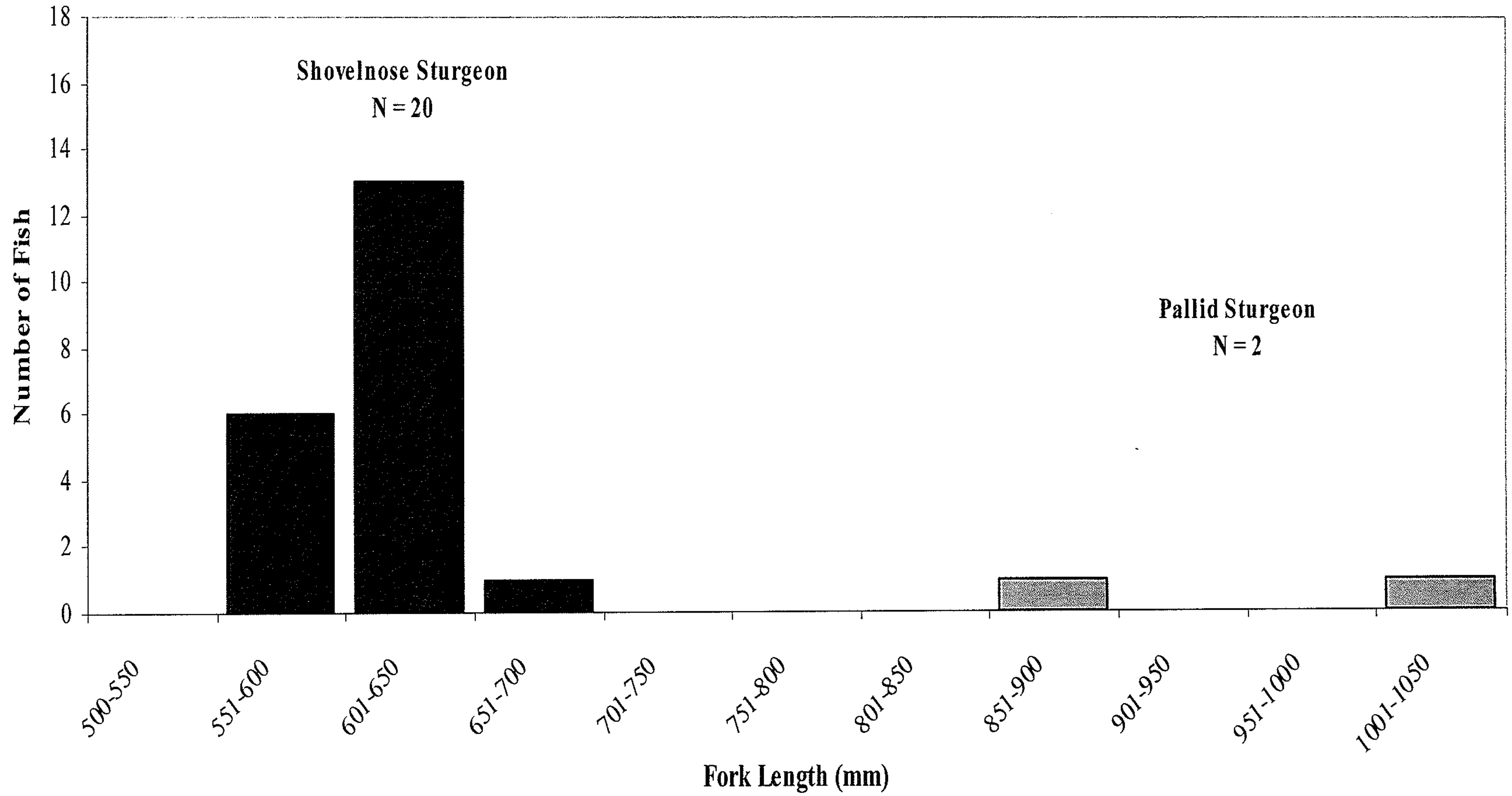

Figure 3. Fork lengths of shovelnose and pallid sturgeon implanted with radio-transmitters in the lower Platte River, Nebraska.

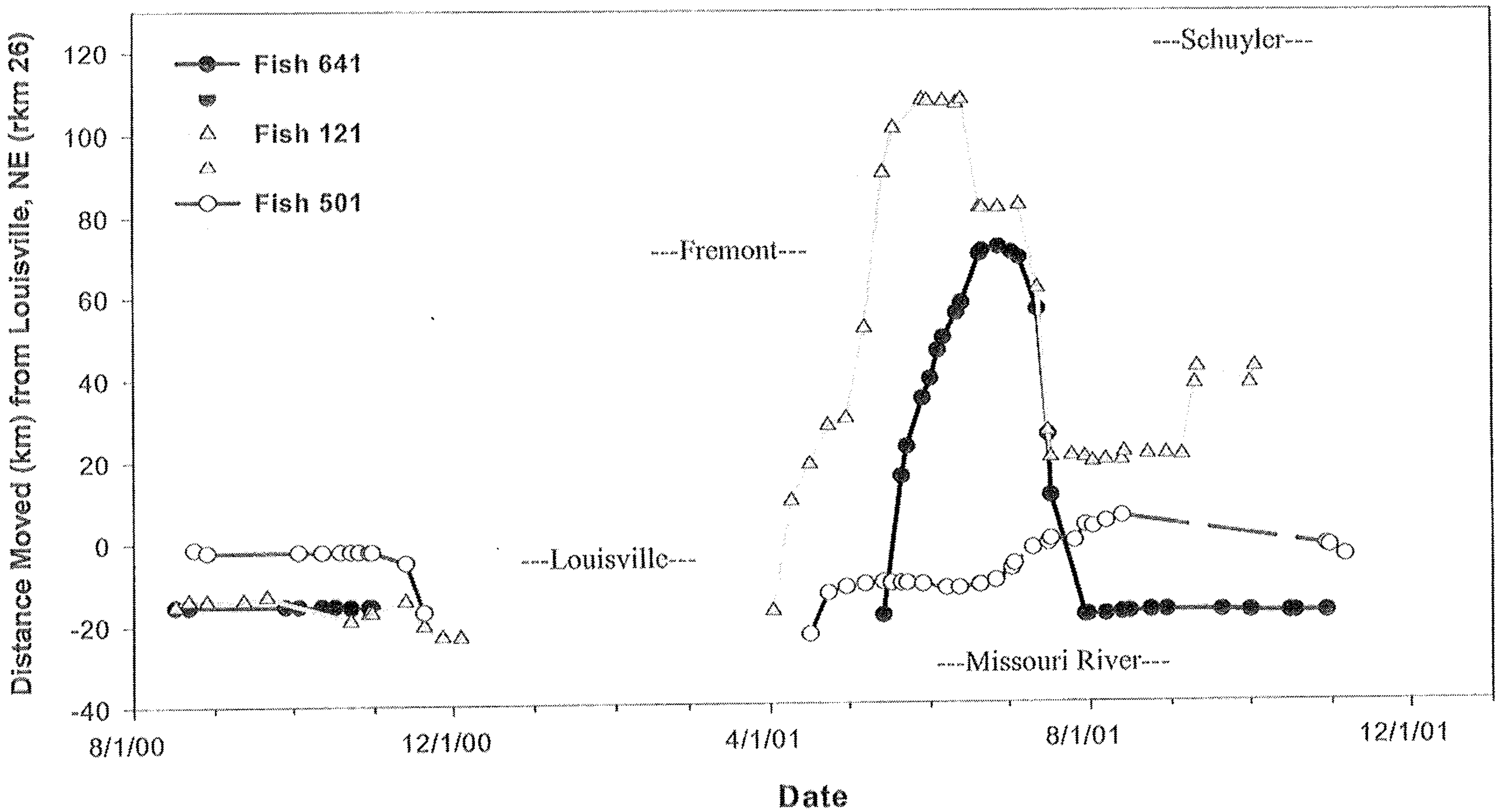

Figure 4. Movements by fish 641, 121, and 501 in the lower Platte River from their respective release sites, August, 2000 through October, 2001.

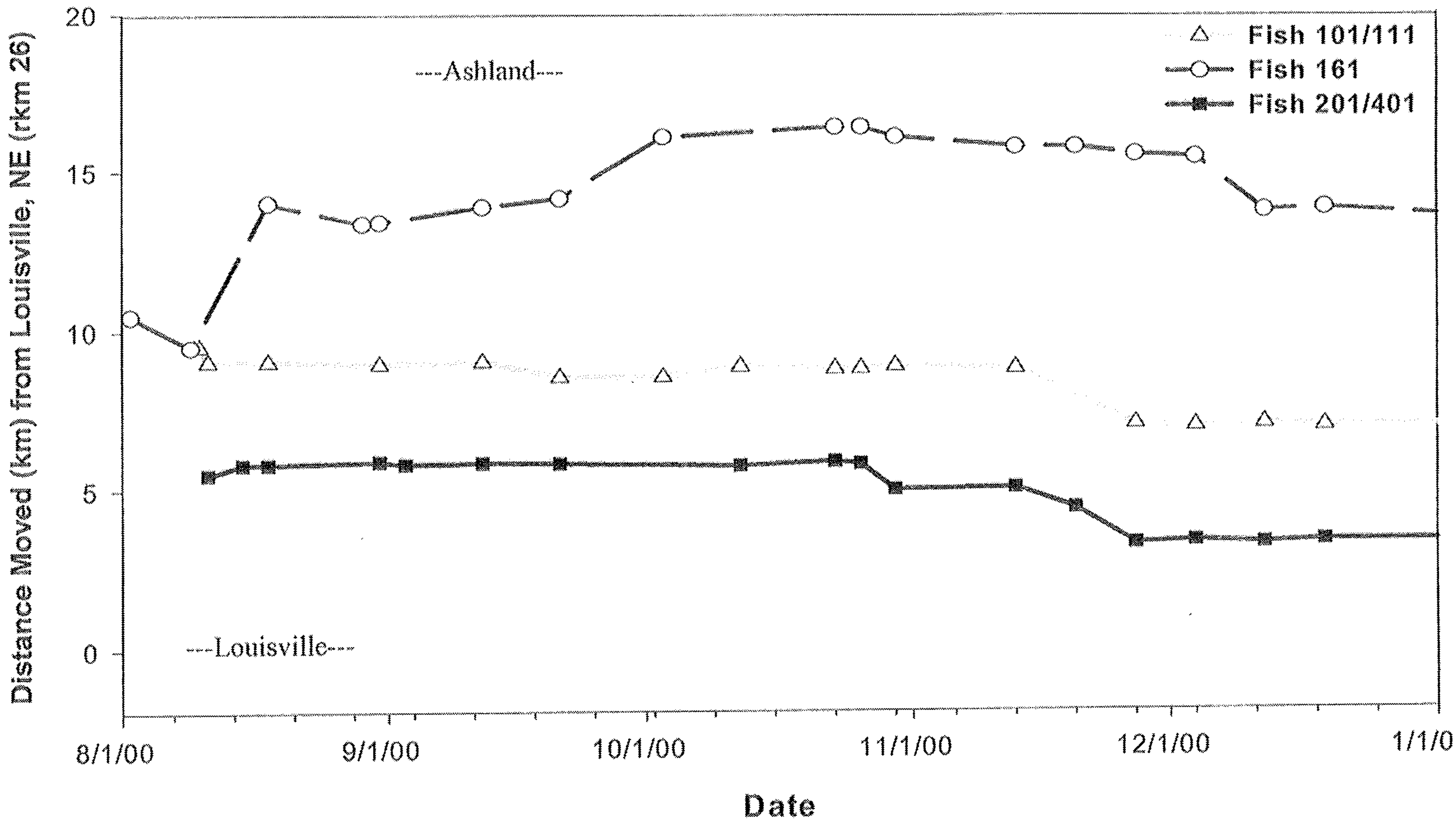

Figure 5. Movements by fish 101, 161, and 201 in the lower Platte River from the respective release sites, August, 2000 through December, 2000.

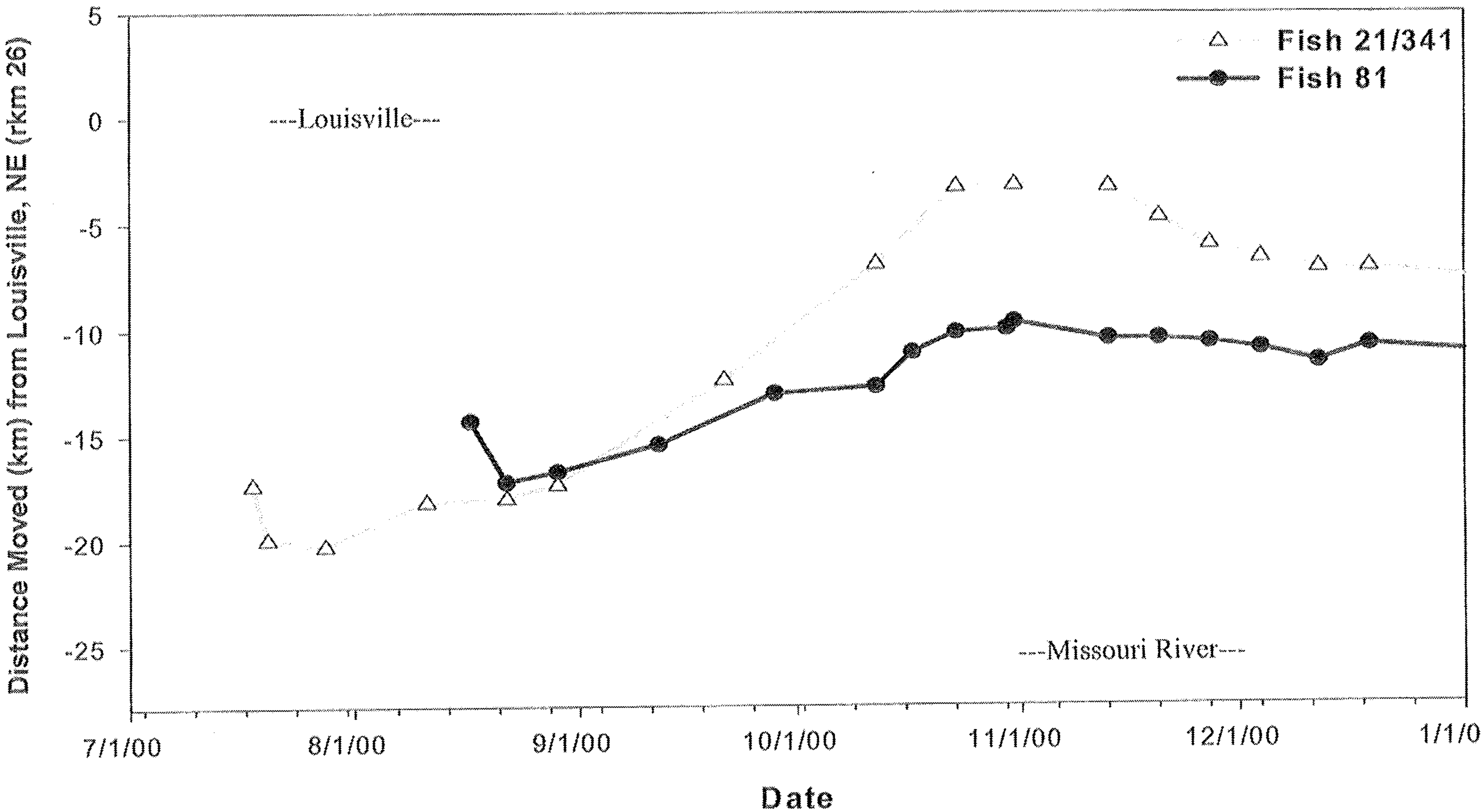

Figure 6. Movements by fish 21 and 81 in the lower Platte River from their respective release sites, August, 2000 through December, 2000

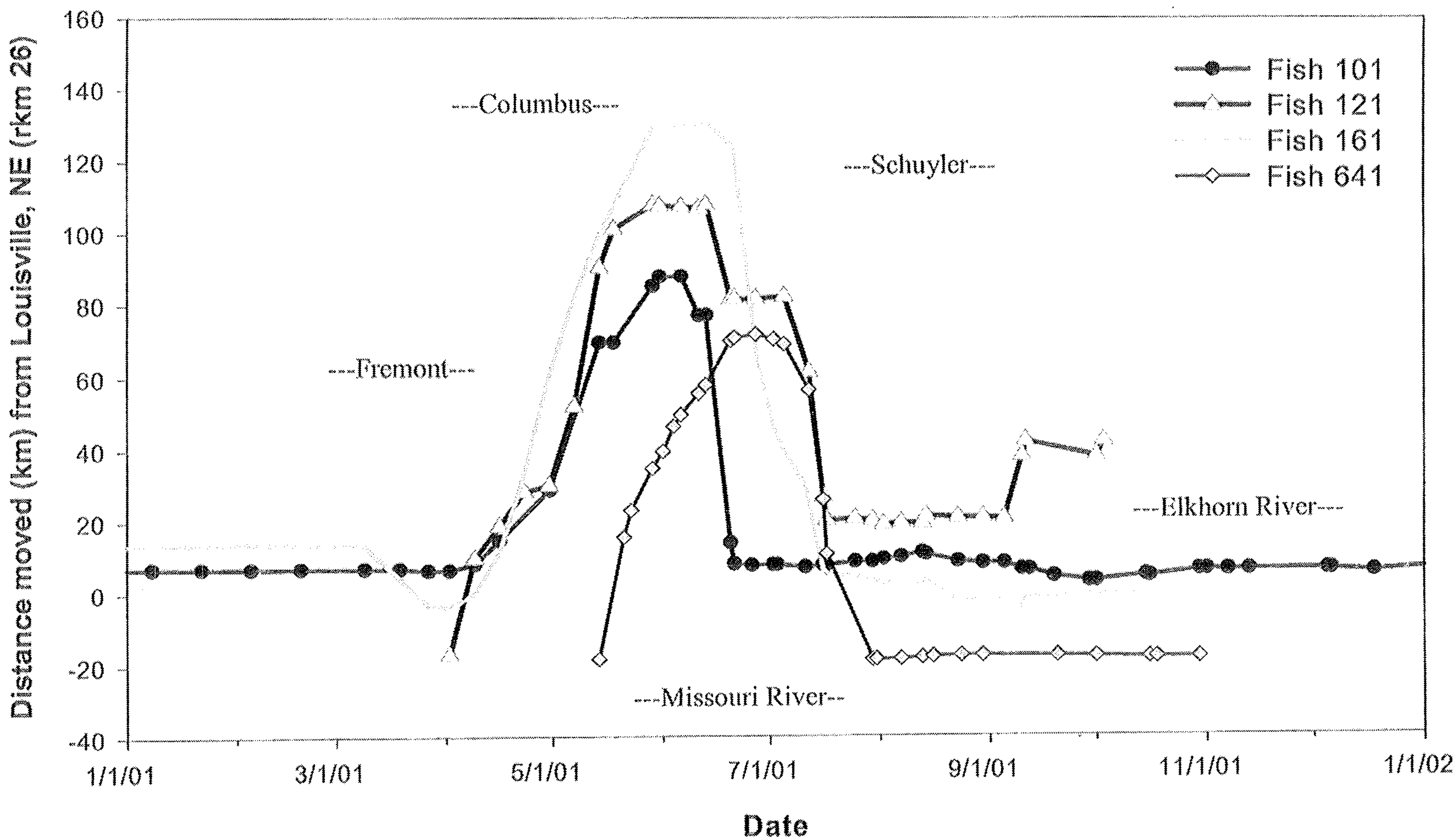

Figure 7. Graph illustrating coordinated upstream and downstream movements by fish 101, 121, 161, and 641 in the lower Platte River, 2001.

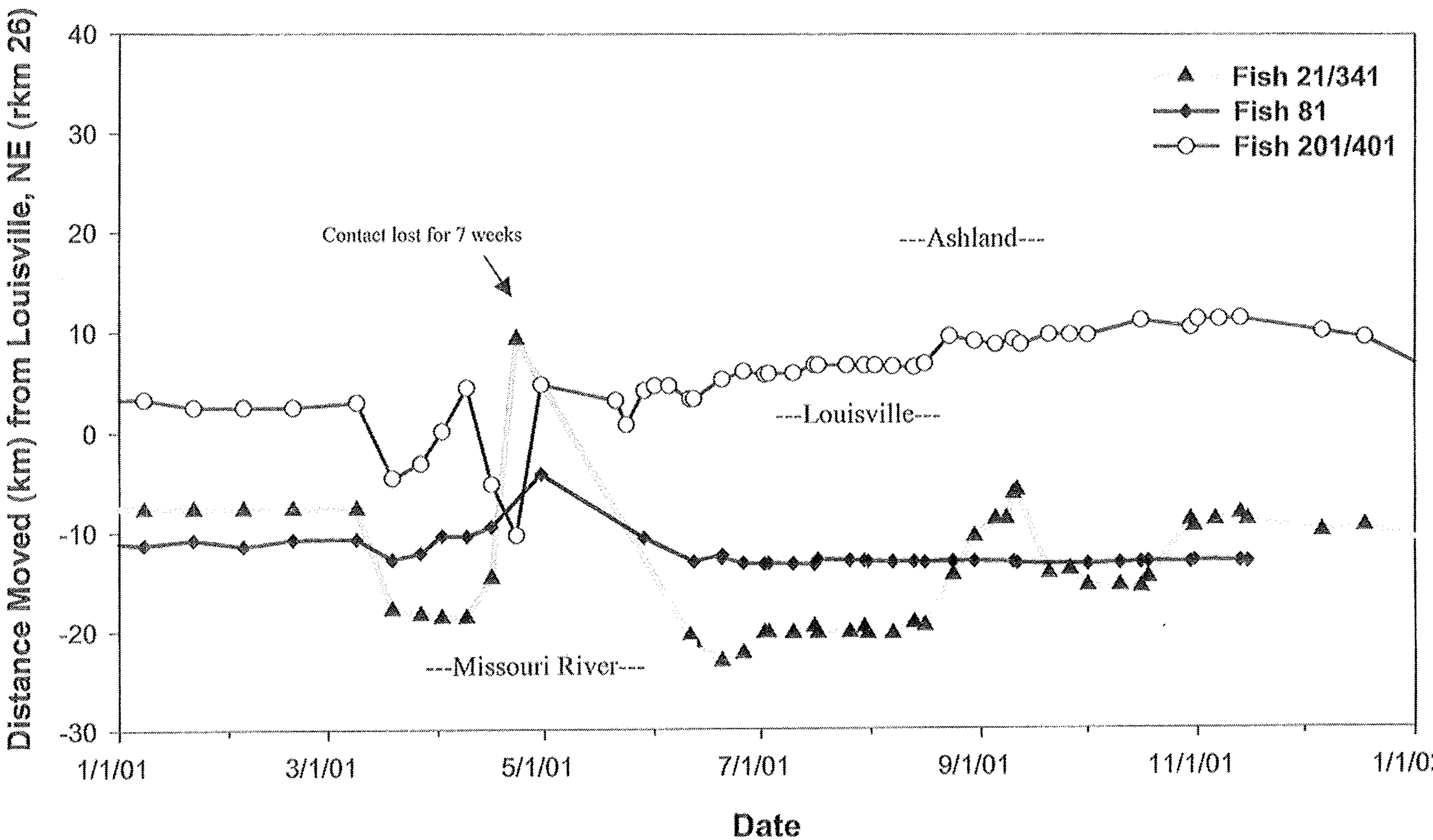

Figure 8. Movements by fish 21, 81, and 201/401 in the lower Platte River, 2001.

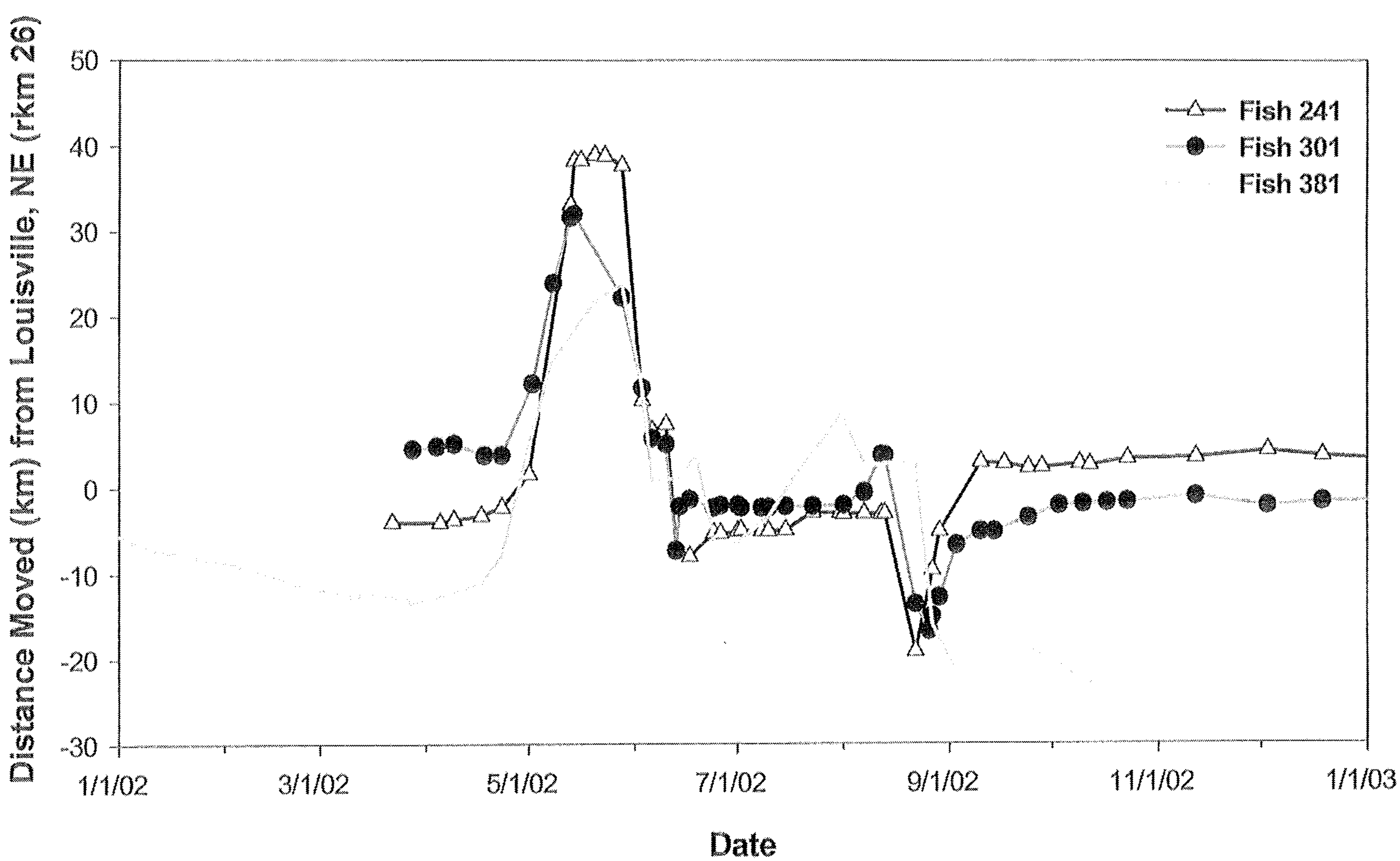

Figure 9. Movements by fish 241, 301, and 381 in the lower Platte River, 2002.

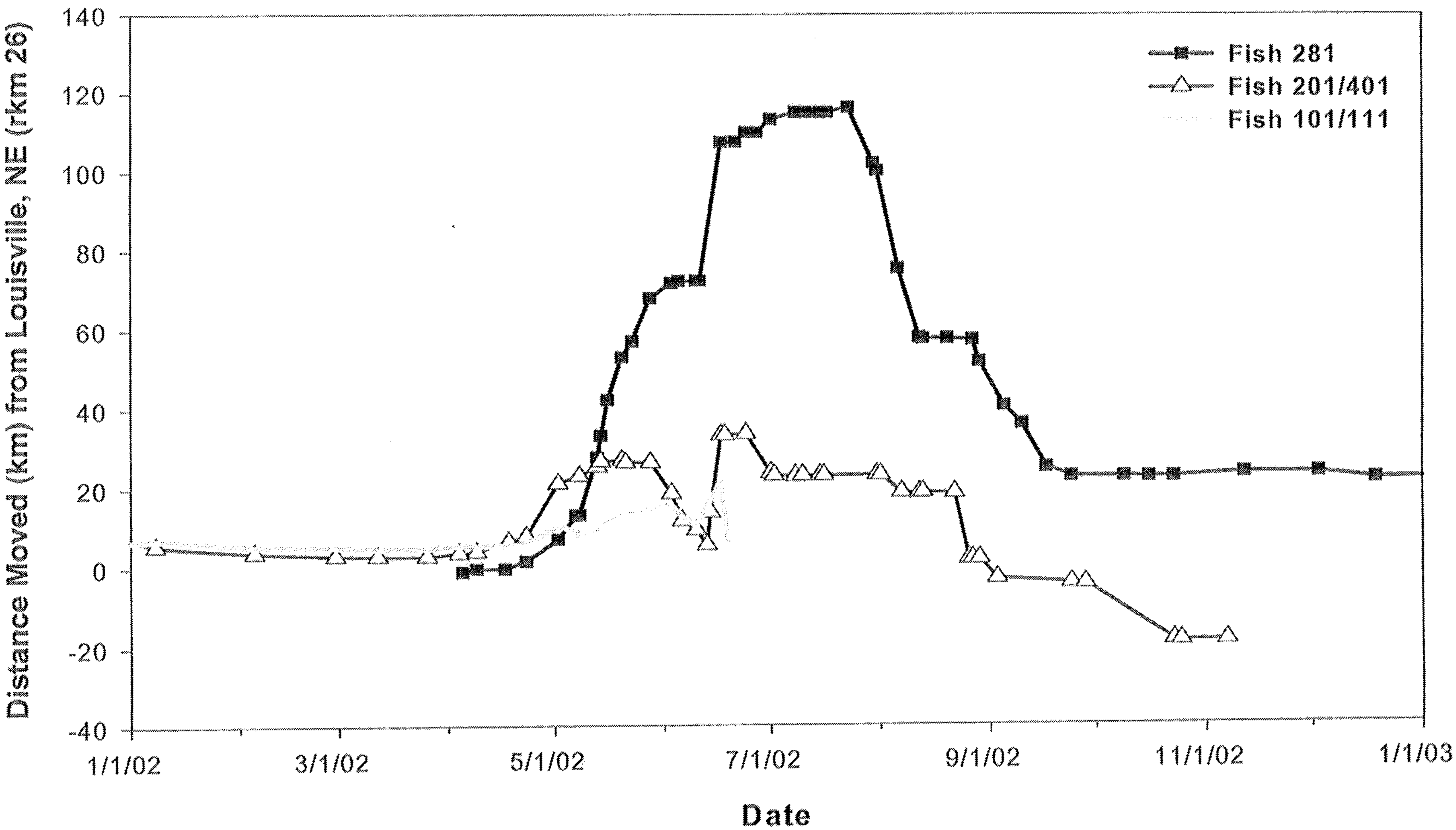

Figure 10. Movements by fish 281, 201/401, and 101/111 in the lower Platte River, 2002.

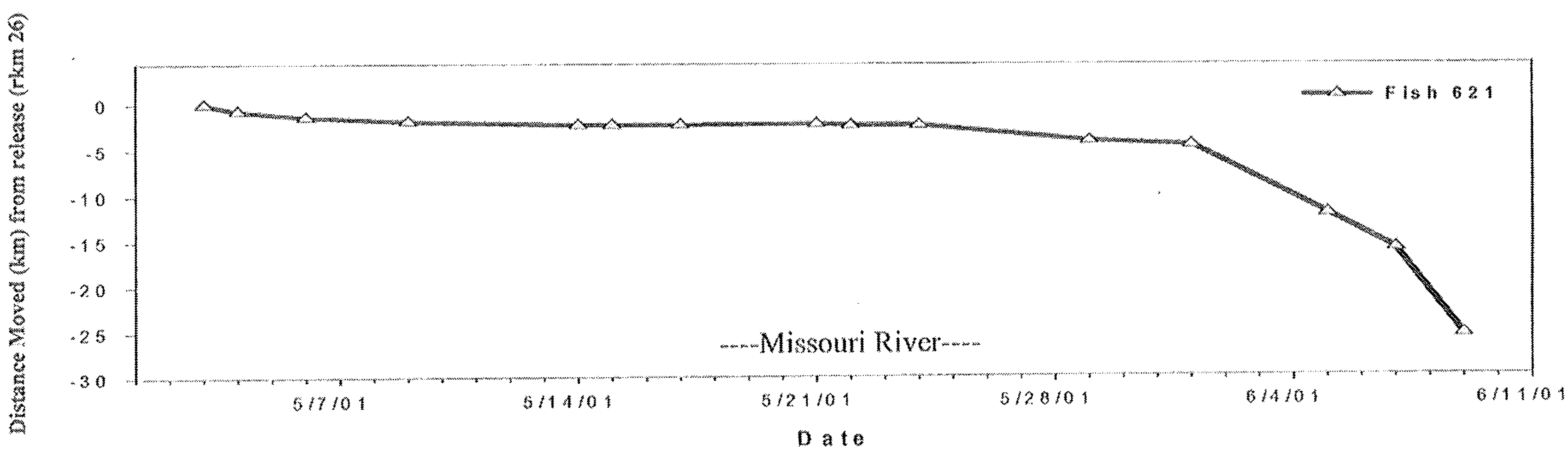

Figure 11. Movement by fish 621 (pallid sturgeon) in the lower Platte River, 2001.

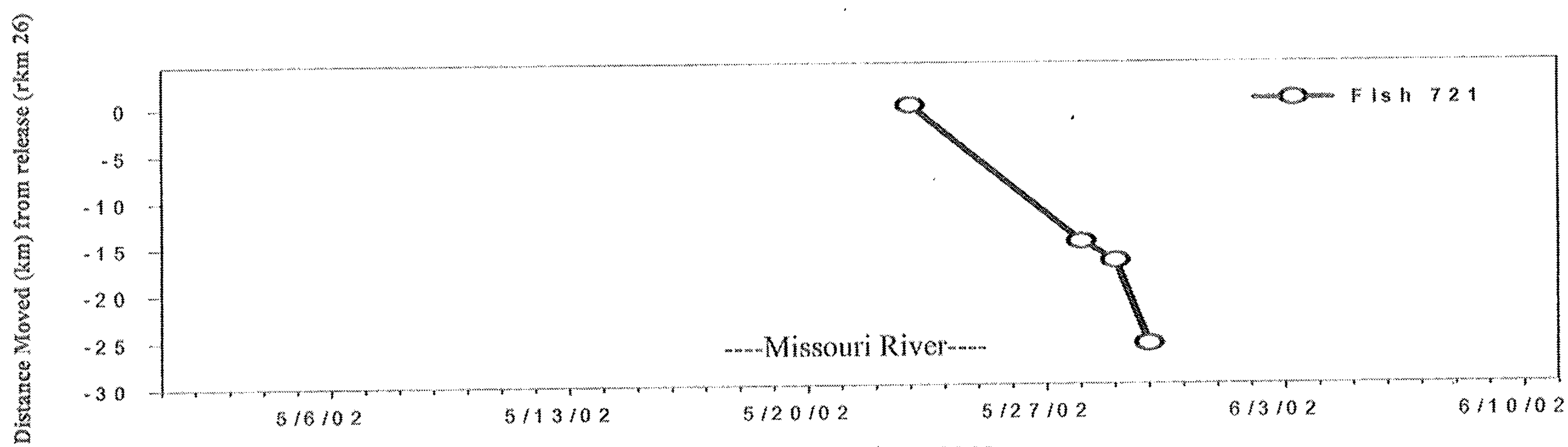

Figure 12. Movement by fish 721 (pallid sturgeon) in the lower Platte River, 2002.

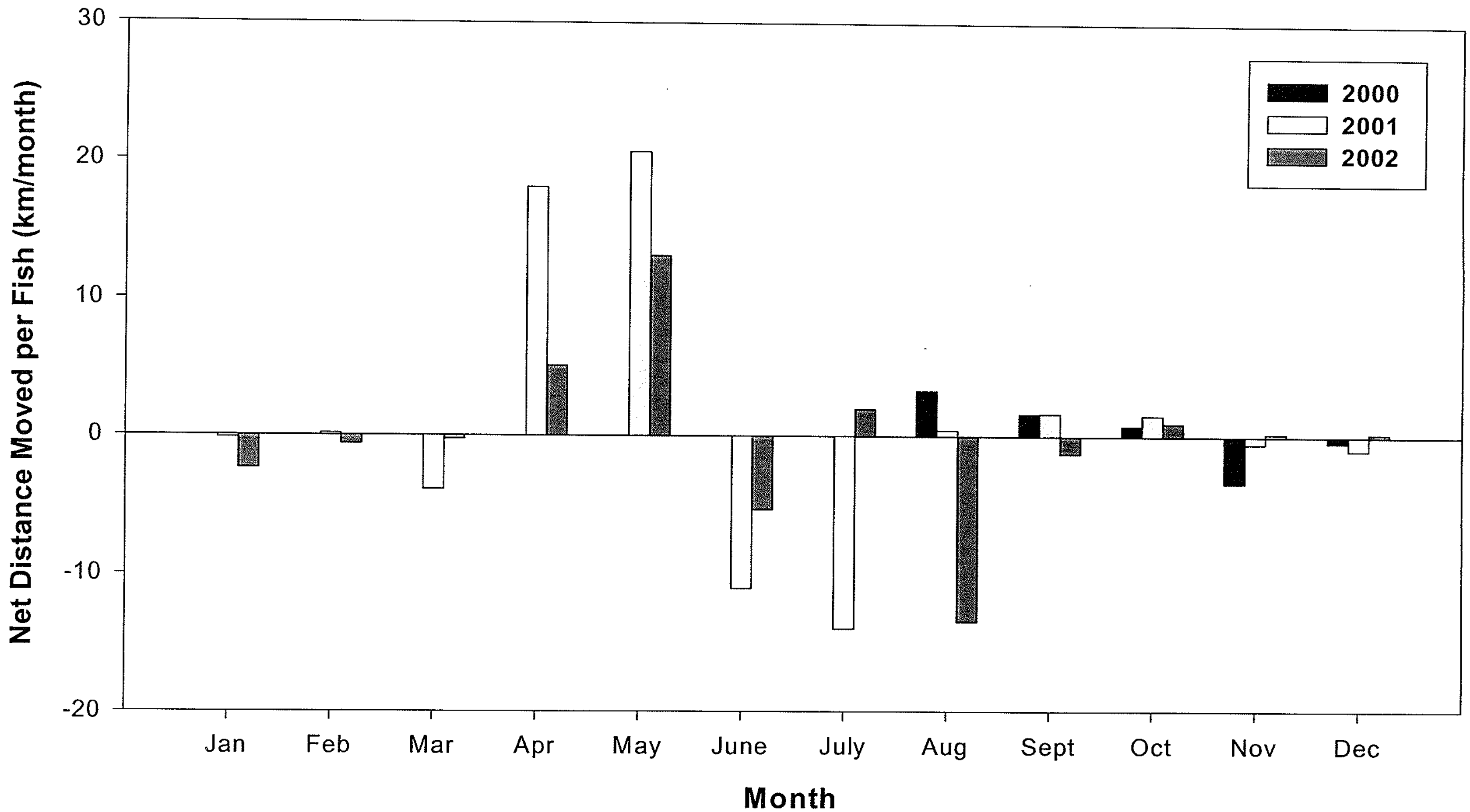

Figure 13. Average monthly net distance (km) moved by radio-tagged shovelnose in the Platte River, August 2000 through December 2002.

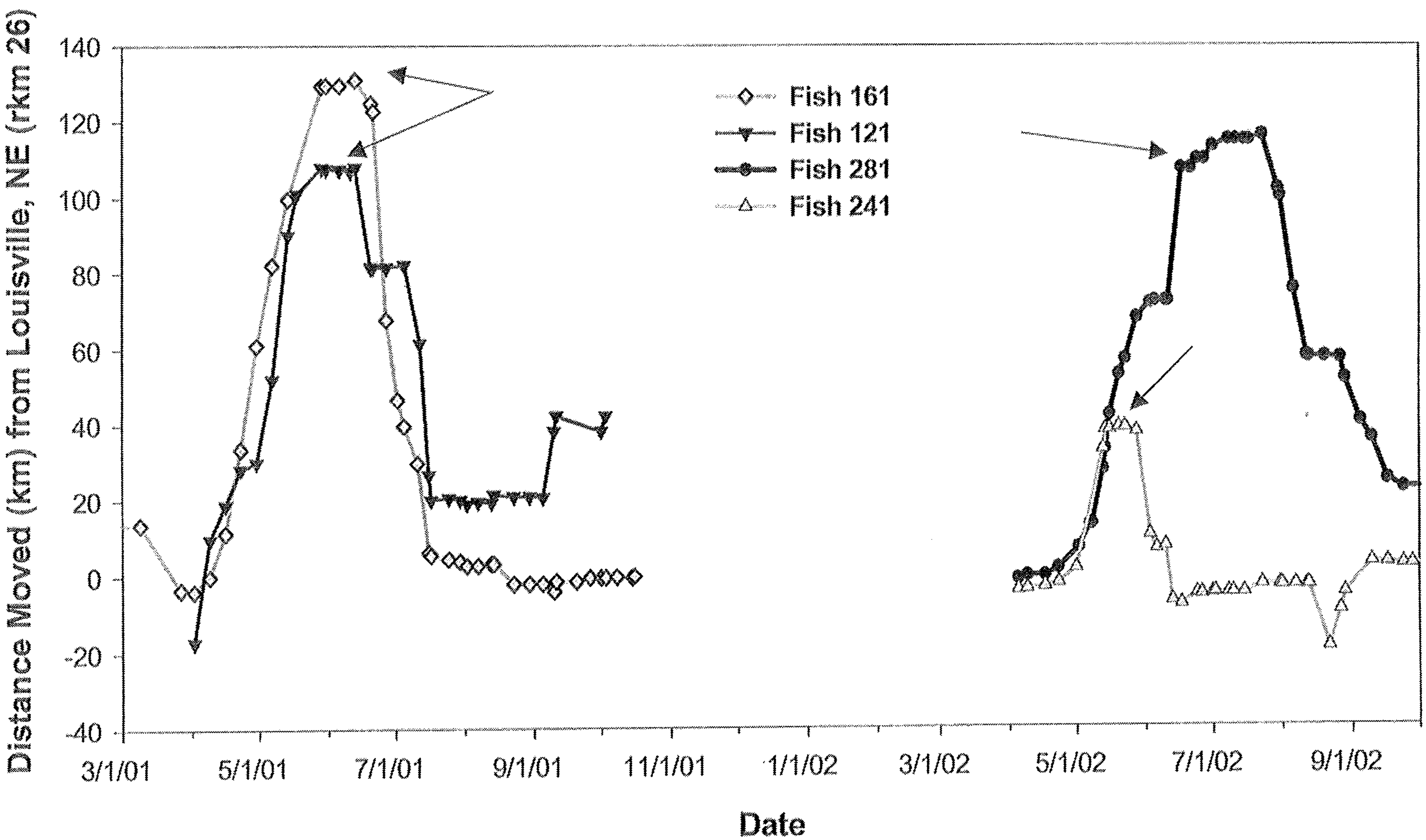

Figure 14. Graph illustrating sedentary periods exhibited by shovelnose sturgeon following long distance upstream migrations in the lower Platte River, 2001 and 2002.

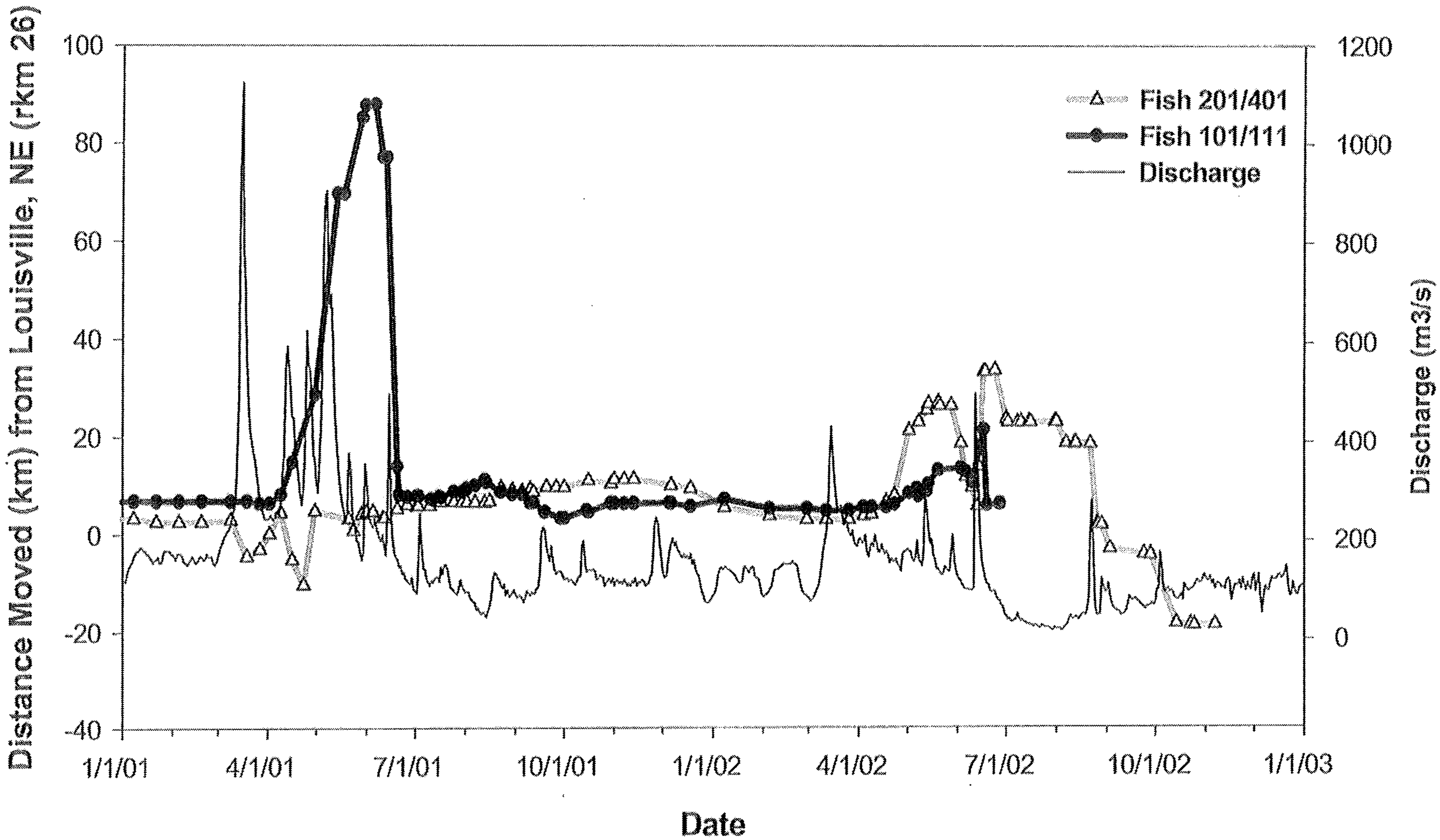

Figure 15. Graph illustrating movement by fish 201/401 and 101/111 in the lower Platte River, 2001-2002.

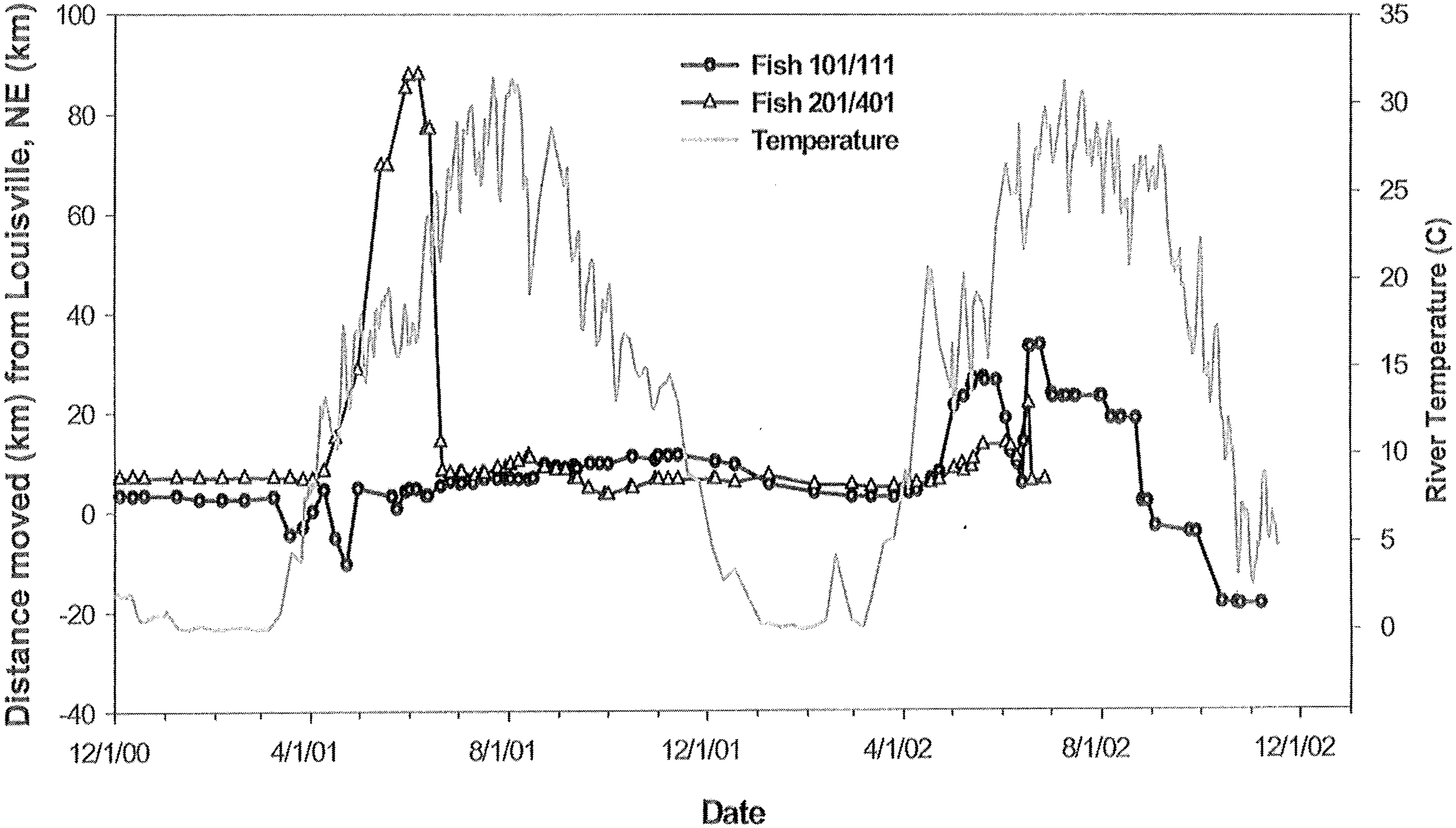

Figure 16. Graph illustrating fish movement versus river temperature (°C).

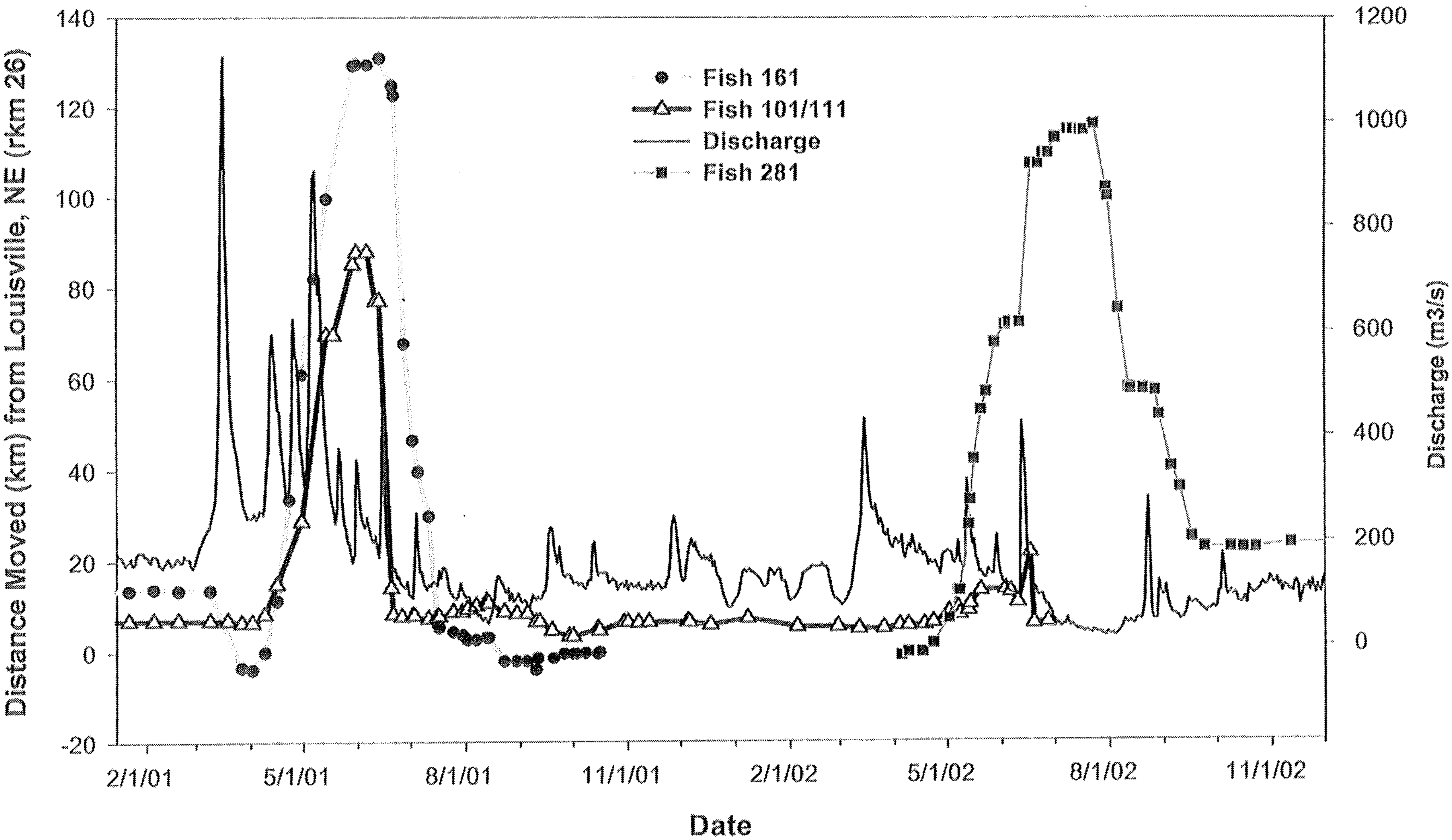

Figure 17. Graph illustrating movement by shovelnose sturgeon versus discharge, 2001-2002 in the lower Platte River, Nebraska.

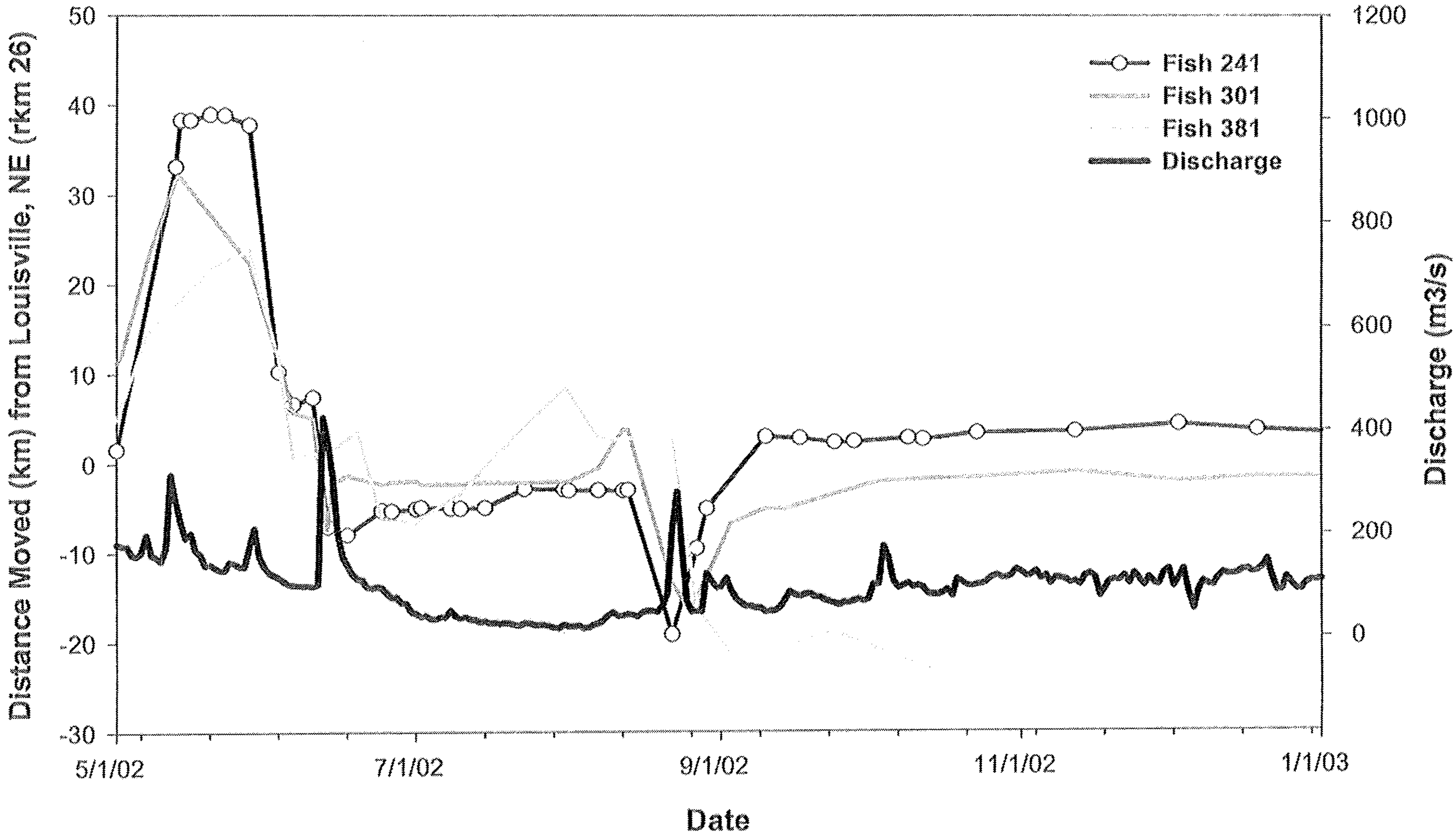

Figure 18. Graph illustrating movement by shovelnose sturgeon versus discharge in the lower Platte River, Nebraska, 2002.

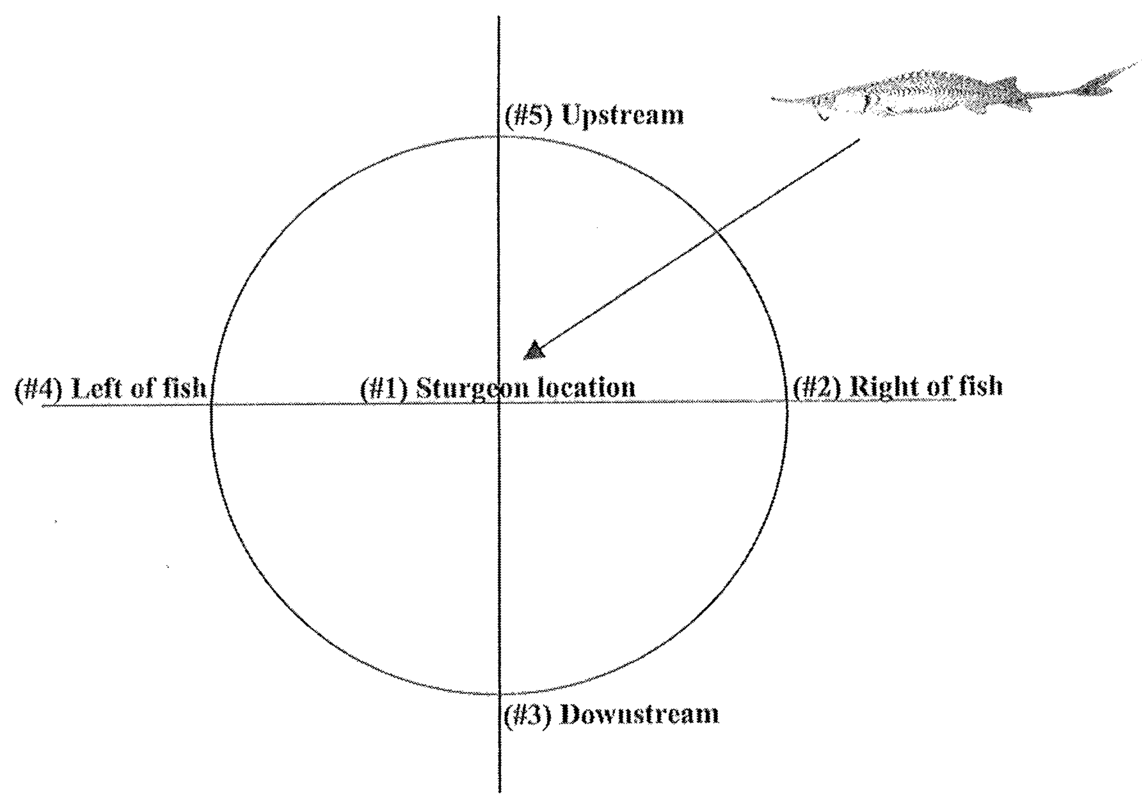

Figure 19. Positions physical habitat measurements were taken to describe habitat use by radio-tagged shovelnose and pallid sturgeon in the lower Platte River, Nebraska.

Figure 20. Picture of characteristic habitat where shovelnose and pallid sturgeon were typically located.

Figure 21. Illustration of underwater sand dunes in the lower Platte River, Nebraska.

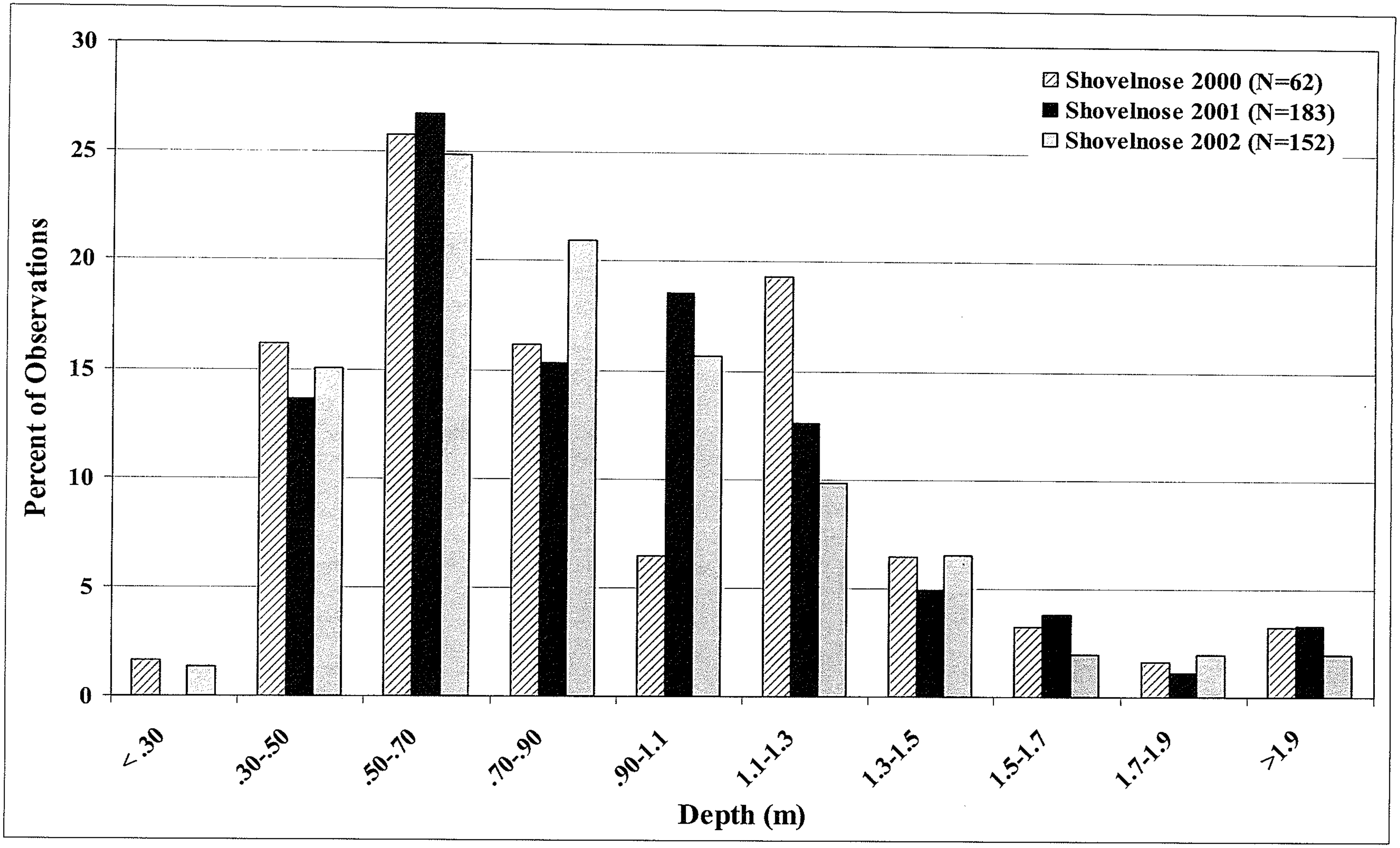

Figure 22. Percent of observations in 0.20 m incremental categories of water depth for radio-tagged shovelnose sturgeon in the lower Platte River, Nebraska, 2000-2002.

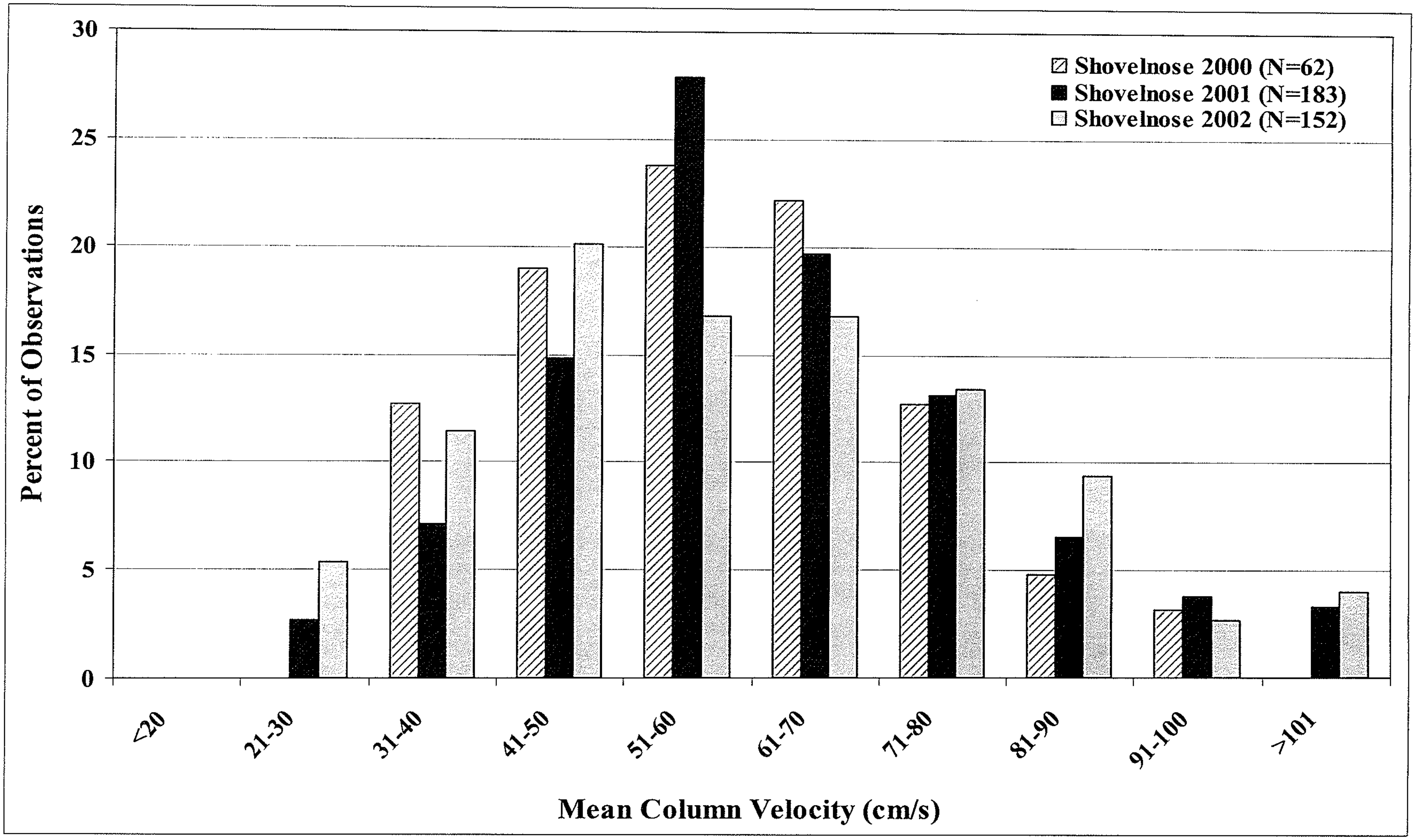

Figure 23. Percent of observations in 10 cm/s incremental categories of mean column velocity for radio-tagged sturgeon in the lower Platte River, Nebraska, 2000-2002.

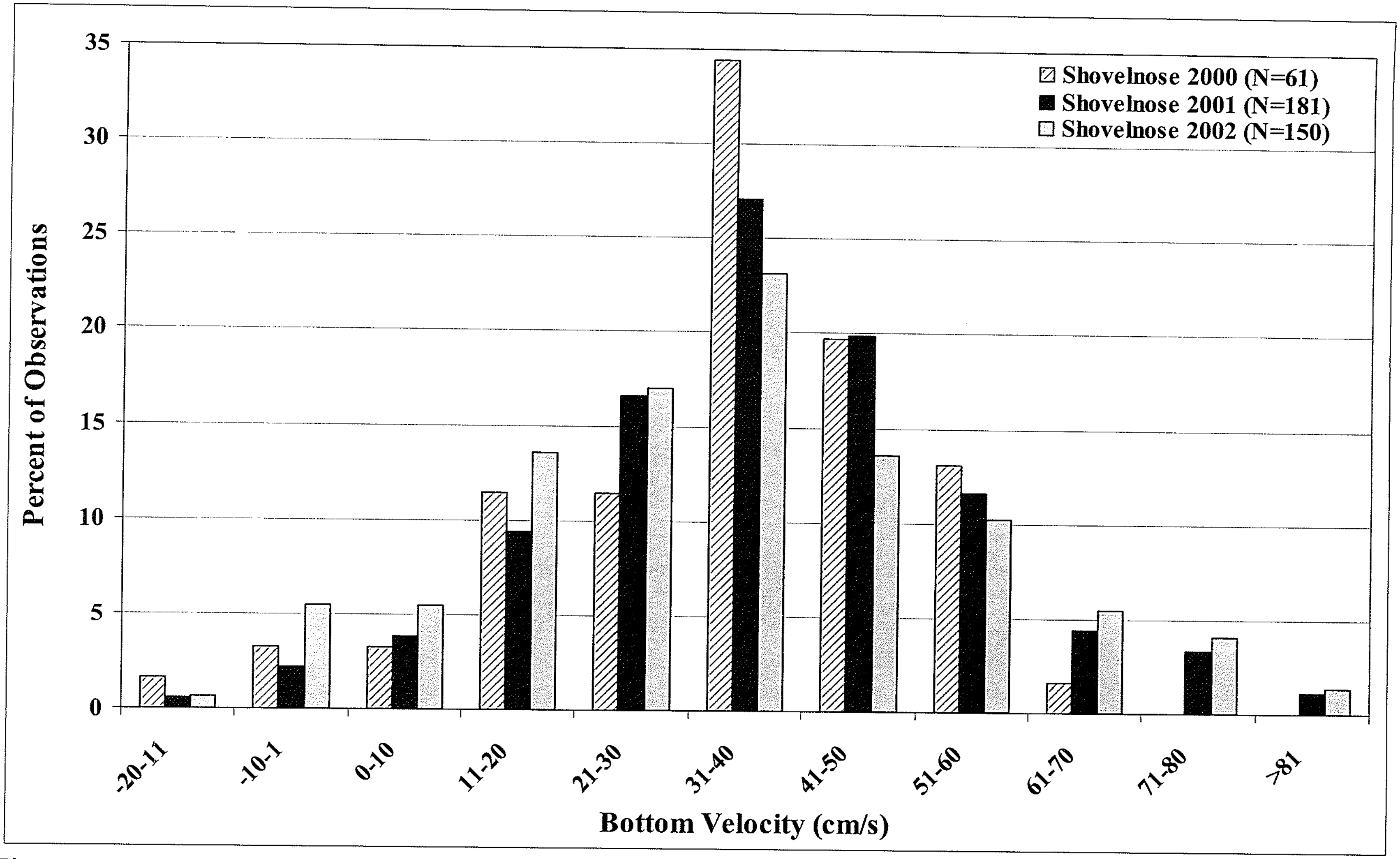

Figure 24. Percent of observations in 10 cm/s incremental categories of bottom velocity for radio-tagged shovelnose sturgeon in the lower Platte River, Nebraska, 2000-2002.

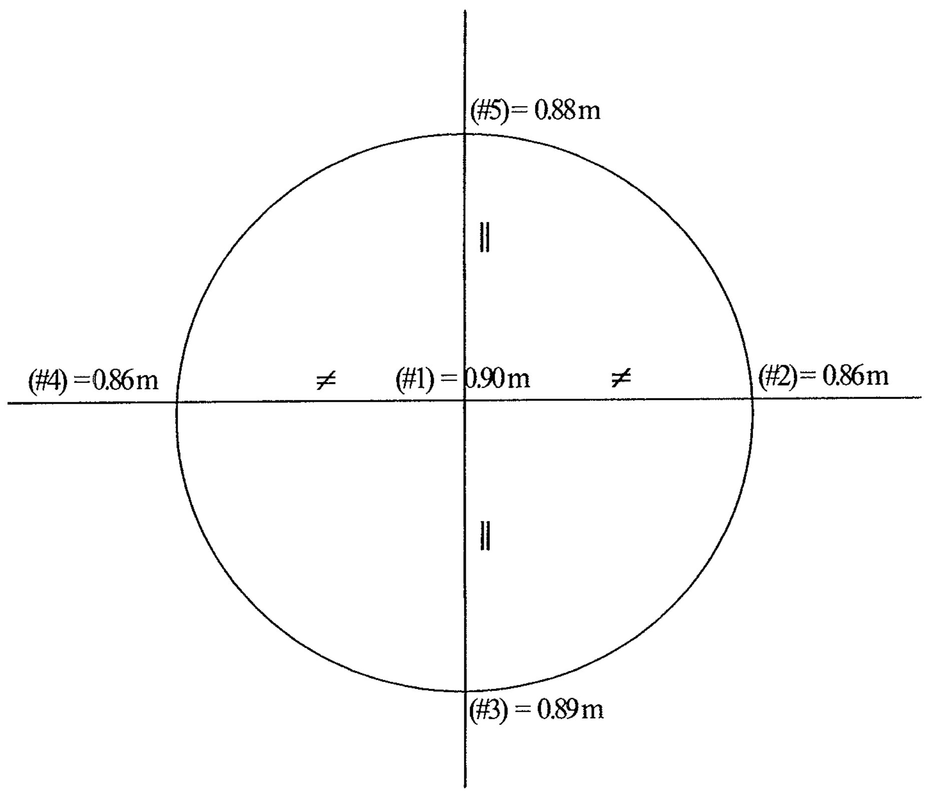

Figure 25. Mean water depths (m) measured over (#1) and at locations surrounding (#2-#5) radio-tagged shovelnose sturgeon in the lower Platte River, Nebraska. Positions designated = were statistically similar, those designated ≠ were statistically different.

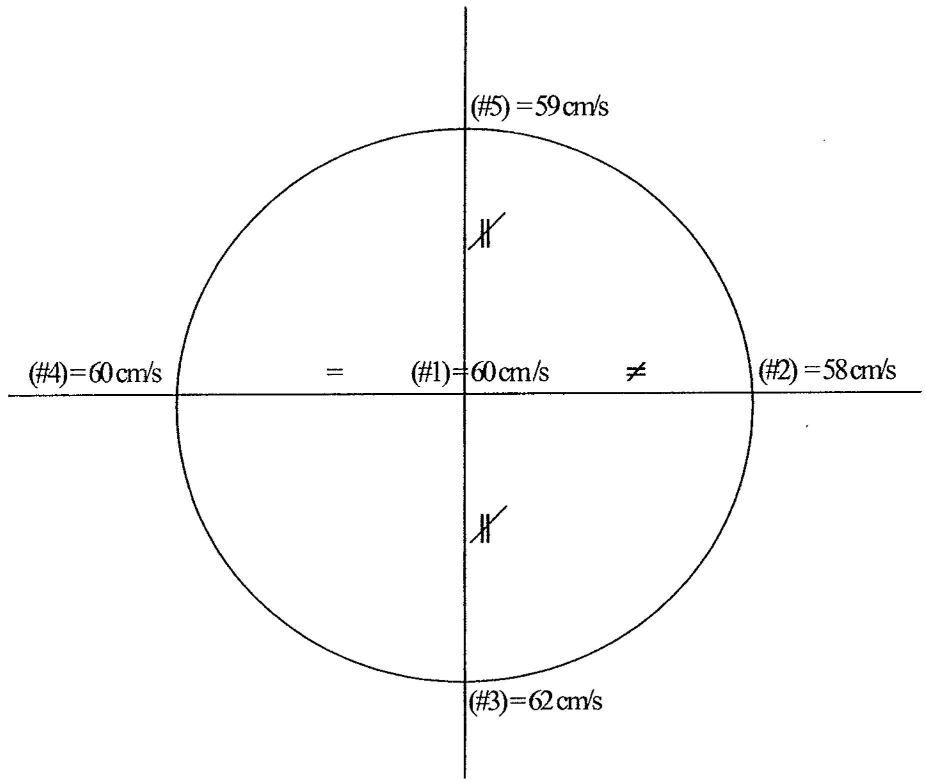

Figure 26. Average mean column velocity (cm/s) measured over (#1) and at locations surrounding (#2-#5) radio-tagged shovelnose sturgeon in the lower Platte River, Nebraska. Positions designated = were statistically similar, those designated ≠ were statistically different.

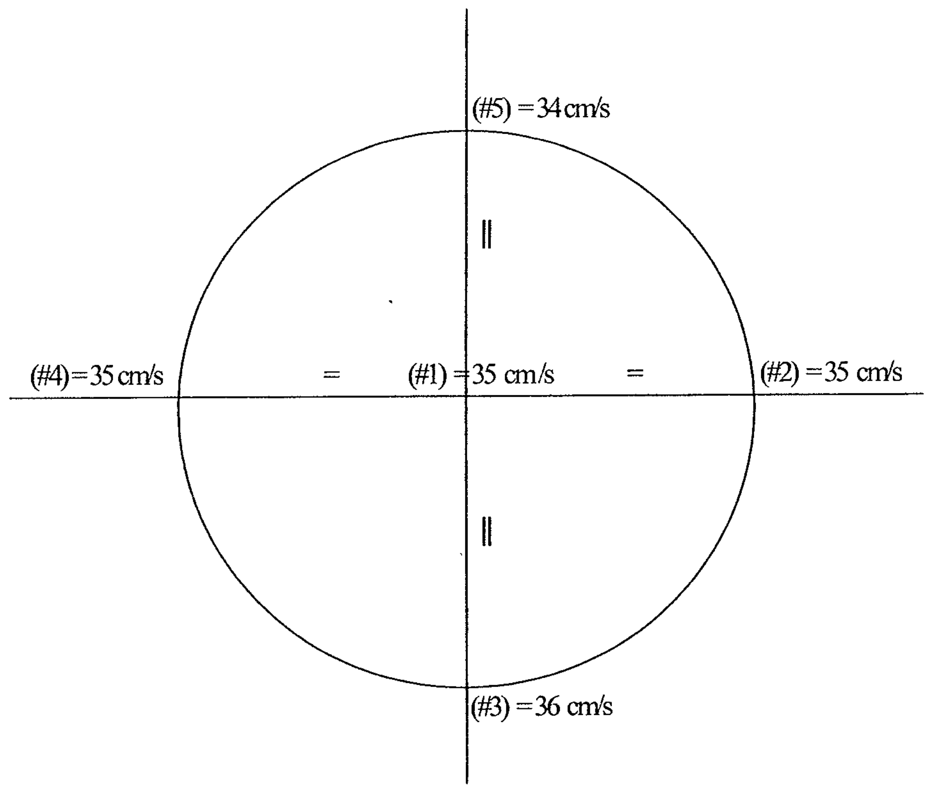

Figure 27. Mean bottom velocity (cm/s) measured over (#1) and at locations surrounding (#2-#5) radio-tagged shovelnose sturgeon in the lower Platte River, Nebraska. Positions designated = were statistically similar, those designated ≠ were statistically different, position #5 was significant slower than #3.

Appendix A-1. Summary of fish implanted with radio-transmitters.

Transmitter frequency	Species	Fork length (mm)	Weight (kg)	P.I.T. Identification Number	Date captured	Date of last location	Battery Life (days)	Aerial Contacts	Airboat Contacts	Greatest Distance between contacts (km)	Final Status
49.021[a]	*S. platorynchus*	598	0.82	-	7/2/2000	7/11/2000	400	0	0	-	dropped
49.021/341[b]	*S. platorynchus*	588	0.75	041828111	7/18/2000	5/20/2002	800	38	35	38.3	expired/lost
49.041	*S. platorynchus*	601	0.79	042045845	8/1/2000	8/31/2000	400	0	0	-	dropped
49.061	*S. platorynchus*	605	0.83	042048523	7/6/2000	8/29/2000	400	0	0	-	dropped
49.081	*S. platorynchus*	574	0.78	042007342	8/17/2000	11/15/2001	400	30	25	13.3	expired
49.101/111[b]	*S. platorynchus*	636	0.91	042050007	8/10/2000	6/19/2002	800	46	40	84.6	expired
49.121	*S. platorynchus*	569	0.82	041860036	8/17/2000	10/3/2001	400	20	23	131.1	expired
49.161	*S. platorynchus*	615	0.85	041864285	8/2/2000	10/16/2001	400	31	29	135	expired
49.181	*S. platorynchus*	605	0.8	042048531	7/17/2000	8/31/2000	400	0	5	8.9	dropped
49.201/401[b]	*S. platorynchus*	610	0.85	042035277	8/10/2000	11/12/2002	800	55	56	53.1	expired
49.241	*S. platorynchus*	626	0.8	4179367444	4/5/2002	1/6/2003	400	19	24	58.2	at large
49.281	*S. platorynchus*	585	0.81	4237751861	4/5/2002	1/6/2003	400	23	23	116.2	at large
49.301	*S. platorynchus*	619	0.94	421E7E6523	3/28/2002	1/6/2003	400	17	27	48.8	at large
49.381	*S. platorynchus*	560	0.77	42377E6B56	10/4/2001	10/23/2002	400	21	27	47.6	expired/MR
49.501	*S. platorynchus*	620	1	042057271	8/24/2000	11/6/2001	625	17	21	26.4	expired
49.521	*S. platorynchus*	628	1.05	-	5/23/2001	4/9/2002	625	18	25	19.6	expired/lost
49.621	*S. albus*	880	2.45	115551734A	5/3/2001	6/9/2001	625	2	10	25.5	expired/MR
49.641	*S. platorynchus*	693	1.25	042034822	8/17/2000	10/30/2001	625	15	23	90.3	expired
49.661	*S. platorynchus*	642	0.97	423A6C3E51	10/8/2001	5/20/2001	625	13	11	17.4	expired/lost
49.721	*S. albus*	1,030	4.1	-	5/23/2002	5/30/2002	625	1	7	25.8	at large/MR
49.821	*S. platorynchus*	638	0.9	4234531571	5/3/2002	9/24/2002	625	4	6	41.8	at large/MR
49.841	*S. platorynchus*	637	1.0[illegible]	42377A123B	5/1/2002	6/5/2002	625	4	5	-	dropped

[a] The transmitter carried by this individual was dropped, recovered and later implanted into a different shovelnose.

[b] These fish were recaptured and implanted with new transmitters prior to the expiration date of the original transmitter.

Appendix B-1. Chemical and physical habitat data collected over fish 21/341from July 20, 2000 to May 8, 2002.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
21/341	7/20/2000	1300	95.92982	41.0575	25.2	10.9	695	210	0, 100, 0	6.60	0.42	0.06
21/341	7/28/2000	1155	95.9235	41.05867	25.2	8.02	750	232	0, 100, 0	0.90	0.47	0.31
21/341	8/11/2000	1108	95.9475	41.0595	26.5	8.73	717	167	0, 100, 0	1.40	0.45	0.16
21/341	8/22/2000	1020	95.95083	41.06033	-	-	-	148	0, 100, 0	2.00	0.54	0.39
21/341	8/29/2000	1100	95.95967	41.06133	-	-	-	112	0, 100, 0	1.80	0.46	0.26
21/341	9/21/2000	1300	96.0177	41.06005	17.6	11.25	1095	-	0, 100, 0	5.50	0.94	0.32
21/341	10/12/2000	1157	96.07902	41.05618	12.1	10.71	647	110	0, 100, 0	1.60	0.67	0.53
21/341	10/31/2000	1300	96.11812	41.03683	16.6	10.35	490	197	0, 100, 0	4.50	0.81	0.16
21/341	6/12/2001	1200	95.9065	41.05865	28	6.92	622	423	0, 50, 50	1.80	0.43	0.38
21/341	6/20/2001	1340	95.8834	41.05481	20.9	9.96	680	183	0, 100, 0	4.95	0.46	0.31
21/341	6/26/2001	1000	95.88943	41.05962	25	10.25	625	178	0, 100, 0	1.65	0.51	0.33
21/341	7/3/2001	1230	95.91887	41.06075	26.3	10.28	692	295	0, 75, 25	1.50	0.58	0.33
21/341	7/10/2001	1040	95.91588	41.0582	28.2	6.65	757	306	0, 100, 0	1.55	0.43	0.38
21/341	7/17/2001	1313	95.91627	41.05778	29.6	11.64	799	194	0, 100, 0	2.90	1.04	0.82
21/341	7/26/2001	1130	95.91805	41.06100	24.3	6.93	693	169	0, 100, 0	2.50	0.71	0.41
21/341	7/31/2001	1630	95.91504	41.05864	32.6	9.36	756	188	0, 50, 50	1.30	0.56	0.19
21/341	8/7/2001	1054	95.91472	41.05931	29.9	8.25	849	-	0, 100, 0	2.95	0.61	0.39
21/341	8/16/2001	1730	95.9231	41.05946	25.6	13.53	920	173	0, 100, 0	1.60	0.28	0.16
21/341	8/24/2001	1205	95.98479	41.05069	26.5	9.67	925	135	0, 100, 0	1.65	0.51	0.33
21/341	8/30/2001	1220	96.02979	41.06547	25.2	10.14	776	115	0, 100, 0	2.05	0.61	0.36
21/341	9/5/2001	1315	96.04977	41.06751	26	10.18	797	-	0, 100, 0	2.15	0.64	0.41
21/341	9/8/2001	1415	96.04988	41.06769	23.2	10.93	787	-	0, 30, 70	1.30	0.73	0.61
21/341	9/11/2001	1110	96.08228	41.05422	20.3	10.66	664	107	0, 100, 0	3.20	0.46	0.33
21/341	9/20/2001	1110	95.98409	41.05093	19.8	8.89	604	-	0, 100, 0	3.10	0.78	0.39
21/341	9/26/2001	1340	95.98904	41.05338	17.8	12.37	547	120	0, 100, 0	1.25	0.47	0.39
21/341	10/10/2001	1325	95.97139	41.05591	16.4	11.03	704	84	0, 100, 0	1.80	0.54	0.42
21/341	10/18/2001	1056	95.97997	41.05351	10.6	10.05	436	145	0, 100, 0	1.60	0.56	0.54
21/341	10/31/2001	1230	96.04128	41.06356	12.2	10.14	551	84	0, 100, 0	5.90	0.84	0.32

Appendix B-1. Continued.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
21/341	11/6/2001	1155	96.04873	41.06786	14.2	10.47	519	81	0, 90, 10	2.15	0.56	0.47
21/341	11/15/2001	1134	96.04908	41.06775	14.8	10.04	552	99	0, 75, 25	2.05	0.70	0.54
21/341	3/13/2002	1214	95.98539	41.05395	4.2	12.55	338	200	0, 100, 0	7.9	0.74	-
21/341	3/28/2002	1510	95.9903	41.05335	10.8	10.55	530	127	0, 100, 0	3.45	0.57	0.41
21/341	4/9/2002	1330	95.99898	41.05719	12	11.33	521	102	0, 100, 0	3.15	0.55	-0.1
21/341	4/17/2002	1432	96.11816	41.03692	21.4	16.34	731	98	0, 100, 0	3.2	0.77	0.73
21/341	5/8/2002	1420	96.29503	41.02504	20.4	8.38	552	257	0, 100, 0	3.95	0.77	0.57

Appendix B-2. Chemical and physical habitat data collected over fish 81 from August 22, 2000 to November 15, 2001.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
81	8/22/2000	1140	95.9472	41.0658	-	-	-	143	0, 100, 0	4.30	0.64	0.35
81	8/29/2000	1000	95.9525	41.0667	24.4	-	-	133	0, 100, 0	3.90	0.66	0.36
81	9/12/2000	1540	95.9672	41.0653	25.5	12.31	773	168	0, 90, 10	3.75	0.35	0.25
81	9/28/2000	1423	95.99243	41.05512	-	-	-	172	0, 100, 0	2.10	0.68	0.54
81	10/12/2000	1115	95.99585	41.05697	11.8	10.75	472	137	0, 100, 0	2.80	0.66	0.47
81	10/17/2000	1235	96.01315	41.06053	17.6	11.14	434	151	0, 80, 20	2.30	0.29	0.07
81	10/31/2000	1220	96.0286	41.06287	16.2	9.94	475	214	0, 100, 0	1.20	0.35	0.2
81	5/29/2001	1330	96.0019	41.05737	20.1	13.34	600	143	0, 100, 0	3.60	1.16	0.71
81	6/12/2001	1230	95.97285	41.05657	28.1	7.3	643	458	0, 100, 0	9.10	0.54	0.36
81	6/20/2001	1245	95.97517	41.05517	21.3	10.08	613	182	0, 100, 0	3.10	0.46	0.31
81	6/26/2001	1100	95.97048	41.0579	24.6	10.15	695	166	0, 100, 0	5.40	0.62	0.35
81	7/3/2001	1145	95.97037	41.05905	26.3	10.63	677	253	0, 100, 0	2.15	0.54	0.29
81	7/10/2001	1115	95.96947	41.058	28.1	7.19	769	241	0, 100, 0	4.05	0.59	0.38
81	7/17/2001	1300	95.97341	41.05558	30	9.41	755	228	0, 100, 0	3.05	0.56	0.39
81	7/26/2001	1100	95.97261	41.05576	24.3	6.88	719	146	-	-	-	-
81	7/31/2001	1540	95.97089	41.05828	32.5	8.63	748	178	0, 100, 0	8.00	1.09	0.58
81	8/7/2001	1014	95.96875	41.05810	28.9	-	866	114	0, 100, 0	3.75	0.76	0.45
81	8/16/2001	1905	95.96399	41.06161	26	13.34	910	176	0, 100, 0	2.50	0.24	0.09
81	8/24/2001	1110	95.97367	41.05526	26.1	8.87	767	143	0, 100, 0	2.10	0.42	0.21
81	8/30/2001	1120	95.97374	41.05529	24.9	8.41	694	-	0, 100, 0	2.05	0.23	0.13
81	9/11/2001	1035	95.96751	41.05832	19.9	10.06	563	123	0, 100, 0	4.10	0.62	0.22
81	10/10/2001	1300	95.96582	41.05821	16.3	11.04	702	84	0, 100, 0	3.30	0.78	0.42
81	10/18/2001	1137	95.97086	41.05756	10.8	10.32	516	118	0, 100, 0	3.00	0.62	0.22
81	10/31/2001	1200	95.97637	41.05456	12.3	10.22	511	98	0, 100, 0	5.15	0.54	0.24
81	11/15/2001	1207	95.97163	41.05697	15.3	10.02	607	71	0, 100, 0	4.10	0.65	0.04

Appendix B-3. Chemical and physical habitat data collected over fish 101/111 from August 11, 2000 to June 19, 2002.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
101/111	8/11/2000	1410	96.23867	41.00733	30.8	10.27	1025	99	0, 100, 0	2.60	0.76	0.35
101/111	8/18/2000	1100	96.23883	41.0065	23.0	10.20	1552	87	0, 100, 0	2.80	0.57	-0.06
101/111	8/31/2000	1310	96.23633	41.005	-	-	-	121	10, 90, 0	1.30	0.49	0.35
101/111	9/12/2000	1105	96.23857	41.00512	21.7	8.96	1565	130	0, 100, 0	1.00	0.58	0.49
101/111	9/21/2000	1630	96.23488	41.00422	17.8	11.52	370		0, 100, 0	1.20	0.55	0.49
101/111	10/3/2000	1425	96.23438	41.00245	19.0	13.54	377	151	0, 100, 0	2.45	0.47	0.3
101/111	10/12/2000	1452	96.23815	41.00545	15.4	10.49	799	94	0, 100, 0	1.60	0.49	0.32
101/111	10/26/2000	1415	96.23583	41.00715	18.0	11.65	396	189	0, 100, 0	2.20	0.36	0.18
101/111	5/18/2001	1237	96.56003	41.43483	21.5	14.80	495	239	0, 80, 20	1.80	0.52	0.39
101/111	5/31/2001	1530	96.77395	41.45265	18.0	11.80	380	128	0, 100, 0	3.50	0.89	0.51
101/111	6/6/2001	1345	96.7774	41.45198	18.9	13.00	375	149	0, 85, 15	1.30	0.69	0.61
101/111	6/13/2001	1404	96.65443	41.43183	25.7	10.34	543	187	0, 50, 50	1.75	0.73	0.18
101/111	6/21/2001	1543	96.25258	41.01773	25.5	11.79	537	225	0, 100, 0	5.65	0.86	0.71
101/111	6/26/2001	1300	96.24775	41.01561	24.9	10.39	908	131	0, 100, 0	2.20	0.45	0.33
101/111	7/3/2001	1000	96.24943	41.0166	24.2	7.59	541	922	0, 25, 75	1.70	0.59	0.36
101/111	7/11/2001	1230	96.24305	41.01458	26.4	9.14	694	188	0, 100, 0	2.50	0.66	0.52
101/111	7/17/2001	830	96.24558	41.01532	26.6	8.46	768	145	0, 100, 0	1.80	0.53	0.28
101/111	7/25/2001	1245	96.25671	41.0195	25.8	8.24	586	175	0, 100, 0	2.30	0.68	0.57
101/111	8/2/2001	1200	96.26289	41.01817	30.6	8.55	931	127	0, 100, 0	2.90	0.56	0.17
101/111	8/7/2001	1246	96.27064	41.0199	31.2	8.64	591	122	0, 100, 0	1.60	0.44	0.31
101/111	8/14/2001	1930	96.27740	41.02273	24.9	-	410	223	0, 100, 0	1.50	0.29	0.15
101/111	8/23/2001	1110	96.26019	41.01699	26.8	8.21	897	125	0, 100, 0	4.15	0.68	0.41
101/111	8/30/2001	1337	96.25468	41.01586	26.0	10.11	904	95	0, 100, 0	1.45	0.36	0.32
101/111	9/5/2001	1142	96.2554	41.01554	24.9	9.50	1148	-	0, 100, 0	1.50	0.49	0.36
101/111	9/12/2001	1245	96.23887	41.00905	24.6	9.97	945	-	-	-	-	-
101/111	9/19/2001	1215	96.21789	40.99431	20.1	8.76	769	253	0, 100, 0	3.05	0.55	0.38
101/111	9/29/2001	1020	96.20325	40.99532	16.3	10.16	480	-	0, 90, 10	1.80	0.41	0.28

Appendix B-3. Continued.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
101/111	10/15/2001	1020	96.22149	40.99525	10.9	10.01	360	203	0, 100, 0	2.40	0.61	0.45
101/111	11/1/2001	1037	96.23931	41.00956	13.6	9.85	445	62	0, 100, 0	2.75	0.35	0.21
101/111	11/7/2001	1117	96.23785	41.00600	15.6	9.84	532	86	0, 100, 0	3.85	0.64	0.35
101/111	12/5/2001	1235	96.24110	41.01009	9.1	11.22	442	216	0, 100, 0	1.90	0.39	0.15
101/111	3/12/2002	1325	96.21987	40.99578	3.4	12.87	327	72	0, 100, 0	3.5	0.83	0.75
101/111	4/4/2002	1431	96.23369	41.00151	8.5	11.52	260	125	0, 100, 0	4.2	0.49	0.17
101/111	4/18/2002	1237	96.24091	41.01323	21	11.46	511	171	0, 100, 0	6.2	1.02	0.72
101/111	5/2/2002	1220	96.28631	41.02042	12.1	13.28	441	87	0, 100, 0	2.55	0.88	0.72
101/111	5/7/2002	1312	96.27482	41.01922	19.7	10.71	421	135	0, 100, 0	2.85	0.37	0.27
101/111	5/14/2002	1211	96.28519	41.02445	15.9	9.14	505	1228	0, 100, 0	2.75	0.61	0.12
101/111	5/20/2002	1750	96.31526	41.05219	21.3	11.28	606	206	0, 100, 0	2.65	0.63	0.42
101/111	6/6/2002	1110	96.31125	41.04615	22.6	12.31	481	128	0, 100, 0	2.8	0.42	0.28
101/111	6/19/2002	1624	96.24456	41.01442	27.9	9.55	536	272	0, 100, 0	1.85	0.46	0.12

Appendix B-4. Chemical and physical habitat data collected over fish 121 from August 22, 2000 to September 11, 2001.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
121	8/22/2000	1250	95.99083	41.05417	-	-	-	166	0, 60, 40	2.30	0.63	0.36
121	8/29/2000	1145	95.9875	41.05417	-	-	-	107	0, 30, 70	1.80	0.56	0.46
121	9/12/2000	1500	95.99183	41.05453	25.2	11.93	776	161	0, 95, 5	1.85	0.51	0.18
121	9/21/2000	1230	96.00317	41.05658	16	11.44	830	-	0, 100, 0	2.65	0.47	0.24
121	10/31/2000	1045	95.95167	41.05855	15.1	9.45	515	233	0, 100, 0	3.70	0.76	0.48
121	5/18/2001	1445	96.90367	41.45655	22.6	15.50	540	182	0, 80, 20	1.55	0.59	0.46
121	5/31/2001	1705	96.97417	41.43618	19.5	11.81	532	67	0, 100, 0	2.40	0.70	0.48
121	6/6/2001	1500	96.97125	41.43843	21.8	12.49	545	154	0, 100, 0	3.60	0.63	0.71
121	6/13/2001	1300	96.97538	41.43697	26.7	9.21	449	89	0, 80, 20	1.85	0.83	0.64
121	6/21/2001	1230	96.67448	41.42718	22.3	13.43	476	154	0, 100, 0	1.95	0.57	0.41
121	6/27/2001	1045	96.67595	41.42638	23.8	11.95	430	74	0, 100, 0	3.35	0.65	0.53
121	7/5/2001	1030	96.68308	41.42675	25.7	10.86	464	122	0, 50, 50	1.80	0.71	0.56
121	7/12/2001	1115	96.45948	41.38687	23.2	9.08	416	48	0, 60, 40	1.75	0.46	0.34
121	7/17/2001	940	96.3247	41.10698	27.1	8.23	448	304	0, 90, 10	3.40	0.50	0.30
121	7/25/2001	1400	96.31876	41.05521	25.6	7.77	533	170	0, 100, 0	1.20	0.34	0.21
121	8/2/2001	1245	96.31893	41.05581	30.8	9.25	576	109	0, 100, 0	1.15	0.53	0.49
121	8/7/2001	1322	96.31374	41.04759	31.1	8.79	544	138	0, 100, 0	2.80	0.53	0.44
121	8/14/2001	1902	96.31351	41.04725	25.3	-	413	126	0, 100, 0	3.00	0.38	0.26
121	8/23/2001	1135	96.31267	41.04761	26.9	10.24	502	215	0, 100, 0	2.25	0.62	0.48
121	8/30/2001	1445	96.32854	41.06816	26.3	10.67	449	137	0, 100, 0	2.15	0.46	0.26
121	9/5/2001	1220	96.32729	41.06493	24.8	8.24	479	-	0, 100, 0	4.25	0.46	0.22
121	9/11/2001	1215	96.32573	41.06174	20.6	10.42	387	123	0, 50, 50	1.90	0.67	0.55

Appendix B-5. Chemical and physical habitat data collected over fish 161 from August 9, 2000 to September 15, 2001.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
161	8/9/2000	1330	96.24533	41.01717	30.8	12.15	566	133	0, 100, 0	1.30	0.54	0.40
161	8/18/2000	1315	96.29317	41.02433	23.8	11.31	1668	89	0, 100, 0	3.80	0.79	0.55
161	8/29/2000	1615	96.2865	41.025	-	-	-	121	0, 90, 10	2.70	0.69	0.56
161	8/31/2000	1215	96.28817	41.02433	-	-	-	140	0, 100, 0	2.20	0.35	0.22
161	9/12/2000	1010	96.29347	41.02442	19.7	9.58	543	111	0, 95, 5	2.20	0.60	0.38
161	9/21/2000	1530	96.29087	41.02855	17.3	11.33	357.6	na	0, 100, 0	2.00	0.46	0.36
161	10/3/2000	1350	96.30972	41.04362	18.7	13.42	384	128	0, 100, 0	2.80	0.70	-0.15
161	10/26/2000	1310	96.31367	41.0474	17.5	11.26	392	199	0, 100, 0	1.90	0.61	-0.01
161	5/31/2001	1140	97.2637	41.38657	17.3	9.26	316.9	157	0, 90, 10	1.80	0.58	0.44
161	6/6/2001	1730	97.26523	41.38798	17.2	12.26	250	104	0, 90, 10	2.80	1.04	0.91
161	6/13/2001	1023	97.27997	41.39877	23.9	10.11	620	159	0, 90, 10	8.30	0.91	0.10
161	6/21/2001	1000	97.1781	41.37767	19.3	10.80	597	58	0, 90, 10	4.10	0.89	0.63
161	6/27/2001	930	96.54755	41.42825	22.4	9.57	391	49	0, 100, 0	3.20	0.44	0.26
161	7/5/2001	1220	96.36567	41.234	28.6	8.40	433	140	0, 100, 0	3.90	0.89	0.17
161	7/11/2001	1315	96.32078	41.1558	26.2	9.10	428	107	0, 50, 50	2.00	0.47	0.44
161	7/17/2001	1130	96.31005	41.03452	28.7	9.34	442	332	0, 100, 0	2.25	0.57	0.47
161	7/25/2001	1315	96.29897	41.02729	25.5	8.44	606	129	0, 100, 0	3.30	0.58	0.42
161	8/2/2001	1215	96.27936	41.02327	31.2	9.11	575	118	0, 90, 10	2.10	0.61	0.49
161	8/7/2001	1305	96.27971	41.02292	31.4	8.56	609	143	0, 100, 0	2.60	0.32	0.22
161	8/14/2001	2130	96.28075	41.02369	24.0	na	403	116	0, 100, 0	4.50	0.89	-0.06
161	8/23/2001	1020	96.22169	40.99740	25.9	9.22	512	216	0, 100, 0	3.40	0.76	0.20
161	8/30/2001	1206	96.20405	40.99765	25.8	12.59	474	108	0, 100, 0	2.20	0.52	0.03
161	9/5/2001	1015	96.20932	40.99426	23.7	8.41	881	-	0, 100, 0	3.00	0.38	0.28
161	9/11/2001	1305	96.24949	41.01711	21.5	13.30	420	125	0, 100, 0	3.80	0.64	0.46
161	9/20/2001	1205	96.24718	41.01722								
161	9/26/2001	1545	96.25961	41.01999	18.6	13.99	445	175	0, 100, 0	3.65	0.95	0.75
161	10/3/2001	1540	96.25675	41.01922	20.1	12.51	494	126	0, 100, 0	3.10	0.61	0.37
161	10/8/2001	1130	96.26014	41.01895	14.2	11.55	450	107	0, 100, 0	3.35	0.65	0.41
161	10/15/2001	1155	96.25182	41.01774	10.9	9.97	338	-	0, 100, 0	3.60	0.62	0.27

Appendix B-6. Chemical and physical habitat data collected over fish 181 from July 20, 2000 to August 31, 2000.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
181	7/20/2000	1600	96.27833	41.02200	27.5	9.74	564	219	0, 100, 0	1.10	-	-
181	7/26/2000	1309	96.27283	41.02000	28.5	8.03	502	-	0, 100, 0	2.00	0.62	0.58
181	7/28/2000	1450	96.27283	41.01950	26.1	7.07	559	119	0, 100, 0	2.20	0.58	0.43
181	8/1/2000	1325	96.27252	41.01797	28.9	8.83	398.1	350	0, 100, 0	4.20	0.84	0.48
181	8/31/2000	1350	96.23417	41.00017	-	-	-	144	0, 95, 5	1.90	0.68	0.51

Appendix B-7. Chemical and physical habitat data collected over fish 201/401 from August 11, 2000 to October 17, 2002.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
201/401	8/11/2000	1315	96.2135	40.9935	29.1	11.17	549	128	0, 100, 0	3.20	0.60	0.35
201/401	8/15/2000	100	96.21717	40.995	26.1	6.31	1110	81	0, 100, 0	4.10	0.52	0.47
201/401	8/18/2000	1000	96.218	40.99533	22.1	10.36	1364	77	0, 100, 0	2.60	0.55	0.40
201/401	8/31/2000	1415	96.21867	40.99567	-	-	-	134	0, 90, 10	2.80	0.51	0.48
201/401	9/3/2000	1515	96.21717	40.99457	18.8	10.06	1054	125	0, 100, 0	3.85	0.47	0.34
201/401	9/12/2000	1245	96.21808	40.99567	22.6	11.57	424.4	122	0, 100, 0	5.40	0.73	0.47
201/401	9/21/2000	1715	96.21787	40.9957	17.8	10.56	371	-	0, 100, 0	4.00	0.39	0.32
201/401	10/12/2000	1345	96.21607	40.9941	15	10.1	444	90	0, 100, 0	1.60	0.41	0.34
201/401	10/26/2000	1513	96.22472	40.99528	18.8	11.46	516	-	0, 100, 0	2.15	0.51	0.44
201/401	5/24/2001	1400	96.17018	41.00958	13.8	10.43	548	277	0, 100, 0	2.55	0.72	-0.12
201/401	6/1/2001	1110	96.21351	40.99348	17	7.71	415.2	670	25, 75, 0	3.90	0.45	0.25
201/401	6/5/2001	1115	96.21345	40.99333	15.8	8.86	626	186	25, 75, 0	3.60	0.58	0.48
201/401	6/12/2001	1418	96.19832	41.00017	29.1	8.25	570	291	0, 100, 0	3.30	0.45	0.32
201/401	6/20/2001	1100	96.22068	40.99663	21.3	9.94	535	214	0, 100, 0	4.10	1.03	0.61
201/401	6/26/2001	1335	96.23045	40.99813	25.2	9.94	825	128	0, 75, 25	2.60	0.54	0.44
201/401	7/3/2001	1033	96.22755	40.99755	24.3	8.28	565	689	0, 100, 0	2.70	0.91	0.78
201/401	7/10/2001	1240	96.22952	41.00092	28.9	7.17	649	-	0, 75, 25	1.90	0.48	0.35
201/401	7/17/2001	810	96.23632	41.0035	26.4	8.06	548	187	0, 100, 0	1.50	0.48	0.32
201/401	7/25/2001	1215	96.23579	41.00409	25.8	8.14	638	183	0, 75, 25	2.70	0.88	0.67
201/401	8/2/2001	1140	96.23533	41.00486	30.5	8.32	607	87	0, 100, 0	1.85	0.44	0.34
201/401	8/7/2001	1400	96.23235	40.99879	32.1	8.97	1115	115	0, 75, 25	2.80	0.58	0.12
201/401	8/16/2001	1750	96.23331	40.99903	26.6	15.23	923	125	0, 100, 0	3.80	0.66	0.27
201/401	8/23/2001	1050	96.26044	41.01698	26.5	7.91	910	143	0, 100, 0	2.85	0.66	0.12
201/401	8/30/2001	1400	96.25539	41.01720	26.5	10.85	683	100	0, 75, 25	1.75	0.51	0.36
201/401	9/5/2001	1125	96.25332	41.01664	24.6	10.03	911	-	0, 100, 0	1.75	0.36	0.26
201/401	9/12/2001	1145	96.25211	41.01591	22.1	10.74	663	96	0, 90, 10	2.25	0.52	0.39
201/401	9/20/2001	1200	96.26063	41.02004	-	-	-	-	-	-	-	-

Appendix B-7. Continued (*12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
201/401	9/26/2001	1545	96.25961	41.01999	18.6	13.99	445	175	0, 100, 0	3.65	0.95	0.75
201/401	10/15/2001	1215	96.27504	41.01914	11.1	10.39	409	-	-	-	-	-
201/401	11/1/2001	1205	96.27252	41.01797	14.5	9.68	903	59	0, 100, 0	4.80	0.70	0.33
201/401	11/7/2001	1057	96.2725	41.01797	15.1	11.42	677	91	0, 100, 0	4.15	0.82	0.58
201/401	12/5/2001	1310	96.25806	41.0167	9.1	11.29	746	170	0, 100, 0	2.50	0.73	0.48
201/401	3/12/2002	1430	96.18577	41.00591	4.1	12.19	338	81	0, 100, 0	4.6	0.79	0.52
201/401	4/4/2002	1344	96.19364	41.00002	7.9	11.56	432	134	0, 100, 0	3.9	0.66	0.58
201/401	4/18/2002	1215	96.22749	40.99647	21.1	10.49	690	119	0, 100, 0	2.25	0.41	0.35
201/401	5/2/2002	1313	96.33795	41.08857	13.1	11.99	428	87	0, 100, 0	5.3	0.72	0.62
201/401	5/8/2002	1530	96.32447	41.10345	20.8	9.5	474	162	0, 100, 0	4.75	0.79	0.42
201/401	5/14/2002	1300	96.31853	41.13487	17.8	10.15	385	384	0, 100, 0	2.45	0.89	0.77
201/401*	5/21/2002	155	96.31809	41.13187	17.7	7.74	388	97	0, 100, 0	2.35	0.82	0.73
201/401	5/28/2002	1813	96.32079	41.13232	26.2	10.81	457	199	0, 100, 0	3.7	0.62	-0.09
201/401*	6/6/2002	1557	96.27228	41.01983	26.8	14.82	445	181	0, 100, 0	3.55	0.32	0.19
201/401	6/13/2002	1252	96.20859	40.99627	23.4	3.74	353	3564	0, 100, 0	1.35	0.63	0.47
201/401	6/14/2002	1254	96.29317	41.02464	21.1	7.26	303	-	0, 100, 0	4.2	1.04	-0.1
201/401	6/18/2002	1033	96.32594	41.18681	22.4	6.94	454	340	0, 100, 0	4.35	0.61	0.36
201/401	7/2/2002	1725	96.33642	41.09538	29.3	14.41	461	147	0, 90, 10	2.2	0.45	0.33
201/401	7/10/2002	1200	96.3372	41.09708	27.8	10.87	458	-	0, 100, 0	3	0.53	0.02
201/401	7/16/2002	1410	96.33723	41.09749	29.7	12.7	457	45	0, 100, 0	4.5	0.62	0.23
201/401*	8/1/2002	915	96.32722	41.10376	25.2	8.99	486	55	0, 100, 0	1.60	0.38	0.33
201/401	8/7/2002	1155	96.32818	41.06702	27.5	10.69	414	89	0, 100, 0	2.25	0.44	0.35
201/401	8/13/2002	1125	96.32777	41.06724	21.6	11.32	360	71	0, 100, 0	1.7	0.31	0.19
201/401	8/22/2002	1335	96.32684	41.06586	29.3	10.78	374	75	0, 100, 0	2.00	0.30	0.26
201/401	8/26/2002	1525	96.17513	41.00837	27.2	10.73	461	131	0, 100, 0	2.65	0.31	0.16
201/401	8/29/2002	1235	96.17525	41.00843	25.2	8.6	398	224	0, 100, 0	3.75	0.58	0.52
201/401*	9/3/2002	1155	96.12756	41.03513	24.8	9.68	364	123	0, 100, 0	3.5	0.71	-0.04
201/401	9/28/2002	1052	96.11613	41.03923	16.1	10.43	833	-	0, 100, 0	1.6	0.28	0.26
201/401	10/17/2002	1303	95.95384	41.05959	9.7	13.61	538	-	0, 100, 0	3	0.47	0.32

Appendix B-8. Chemical and physical habitat data collected over fish 241 from April 9, 2002 to October 12, 2002 (*12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
241	4/9/2002	1455	96.12553	41.03615	13.1	11.1	558	119	0, 100, 0	7.1	0.74	0.45
241	4/17/2002	1236	96.13088	41.03454	19.4	16.04	476	146	0, 100, 0	3.2	0.76	0.68
241	5/1/2002	1311	96.17738	41.00481	16.3	11.14	627	109	0, 100, 0	2.95	0.85	0.57
241	5/14/2002	1410	96.36094	41.24184	19.3	10.41	382	259	0, 100, 0	4.9	1.04	0.34
241*	5/16/2002	1400	96.36041	41.24227	19.2	10.02	398	208	0, 100, 0	2.25	1.19	0.91
241	5/23/2002	1105	96.35352	41.24842	15.5	10.02	398	-	0, 100, 0	2.4	0.87	0.72
241*	6/6/2002	1012	96.25029	41.01780	21.7	11.96	471	151	0, 100, 0	1.35	0.39	0.23
241	6/13/2002	1428	96.11692	41.04138	23.7	3.87	358	3040	0, 100, 0	2.65	0.75	0.57
241	6/17/2002	1410	96.10738	41.04776	25.9	9.25	576	585	0, 100, 0	0.8	0.39	0.29
241	6/24/2002	1404	96.13332	41.02691	29.3	10.06	1168	148	0, 100, 0	1.35	0.44	0.34
241*	6/26/2002	150	96.13197	41.02783	28.1	6.17	1178	112	0, 100, 0	3.5	0.91	0.59
241	7/2/2002	1825	96.13907	41.02139	29.9	11.39	791	154	0, 100, 0	2.3	0.31	0.23
241	7/10/2002	1340	96.13657	41.02275	27.7	10.67	1035	143	0, 100, 0	2.3	0.57	0.32
241	7/15/2002	1840	96.13713	41.02277	31.9	12.31	1271	101	0, 75, 25	2.2	0.53	0.45
241	7/23/2002	1535	96.15681	41.01305	30.6	12.76	809	42	0, 100, 0	3.35	0.62	-0.09
241	8/1/2002	1407	96.15285	41.01599	29.4	10.26	936	94	0, 100, 0	1.05	0.28	0.24
241	8/7/2002	1100	96.15475	41.01393	27.1	11.58	1493	123	0, 50, 50	1.4	0.51	0.42
241	8/13/2002	1215	96.1547	41.01396	22.6	12.29	1107	109	0, 90, 10	1.75	0.56	0.43
241	8/22/2002	1715	95.9776	41.05403	26.6	4.04	994	2196	0, 100, 0	4.35	0.87	0.64
241	8/29/2002	1045	96.13827	41.02684	24.5	7.13	483	515	0, 100, 0	2.35	0.41	0.2
241	9/17/2002	1043	96.21815	40.9952	19.4	10.02	674	-	0, 100, 0	5.2	0.73	0.02
241	9/28/2002	1300	96.21365	40.99537	17	11.93	364	-	0, 100, 0	2.00	0.44	0.12
241	10/9/2002	1300	96.21863	40.99546	17.7	12.52	345	-	0, 100, 0	2.10	0.61	0.52
241	10/12/2002	1008	96.21703	40.99519	15.1	9.31	370	-	0, 100, 0	3.5	0.62	0.1

Appendix B-9. Chemical and physical habitat data collected over fish 281 from April 17, 2002 to October 16, 2002 (*12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
281	4/17/2002	1215	96.15832	41.01283	19.4	16.15	474	120	0, 100, 0	2.85	0.81	0.63
281	5/2/2002	1154	96.23574	41.00402	12.4	12.51	401	135	0, 100, 0	2.75	0.69	0.41
281	5/7/2002	1331	96.29793	41.02877	20.3	9.18	468	169	0, 100, 0	1.25	0.45	0.42
281	5/14/2002	1341	96.33078	41.19612	18.7	10.15	371	295	0, 100, 0	5.5	1.06	0.04
281*	5/16/2002	1558	96.35470	41.27198	20.1	10.05	394	196	0, 75, 25	1.55	0.32	0.17
281	5/23/2002	1150	96.4529	41.38092	16.3	10.41	384	-	0, 100, 0	1.5	0.59	0.46
281	6/5/2002	1225	96.613	41.44178	21.9	11.61	408	-	0, 100, 0	3.6	0.61	0.39
281	6/11/2002	1110	96.61572	41.44247	24.1	9.78	336	285	0, 100, 0	3	0.63	-0.13
281*	6/21/2002	153	97.01846	41.41592	24.5	6.59	398	77	0, 100, 0	2.7	0.51	0.39
281	6/27/2002	1000	97.04676	41.41535	25.6	8.72	335	50	0, 90, 10	1.85	0.42	0.32
281	7/1/2002	1203	97.08694	41.39711	27.2	6.81	392	33	0, 80, 20	2	0.31	0.29
281*	7/11/2002	1758	97.10471	41.38824	25.2	7.63	378	25	0, 75, 25	0.90	0.73	0.60
281	7/17/2002	1237	97.09804	41.38822	29.4	7.38	376	23	0, 75, 25	1.6	0.27	0.16
281	7/23/2002	1155	97.11203	41.38824	26.3	9.05	412.2	20	0, 50, 50	1.75	0.65	0.51
281	7/30/2002	1035	96.95715	41.44267	27.1	6.97	410	26	0, 75, 25	1.6	0.47	0.36
281*	8/6/2002	205	96.64870	41.43550	26.2	6.18	373	84	0, 100, 0	1.9	0.45	0.33
281	8/13/2002	1550	96.45809	41.38521	27.4	7.97	369	34	0, 100, 0	1.65	0.26	0.2
281	8/20/2002	1025	96.45991	41.38667	21	9.47	259	83	0, 100, 0	2.5	0.53	0.35
281	8/29/2002	1355	96.40654	41.33796	24.2	10.79	281	84	0, 100, 0	2.5	0.47	0.31
281	9/5/2002	1350	96.35382	41.24866	27.4	8.86	330	104	0, 100, 0	1.8	0.39	0.08
281	9/17/2002	1140	96.31043	41.11522	19.1	12.3	383	-	0, 100, 0	1.9	0.48	0.3
281	10/9/2002	1440	96.33456	41.09732	16.8	12.69	409	-	0, 100, 0	1.1	0.32	0.13
281	10/16/2002	1215	96.33551	41.09629	9.4	12.58	80	-	0, 100, 0	1.3	0.41	0.4

Appendix B-10. Chemical and physical habitat data collected over fish 301 from April 4, 2002 to October 17, 2002 (*12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
301	4/4/2002	1410	96.2093	40.99542	8.1	12.68	363	136	0, 90, 10	2.75	0.62	0.12
301	4/18/2002	1200	96.19714	40.99766	20.5	9.92	718	151	0, 100, 0	2.05	0.46	0.38
301	5/2/2002	1233	96.28591	41.0203	12.2	13.35	426	87	0, 100, 0	3.5	0.92	0.13
301	5/8/2002	1510	96.31699	41.10679	20.7	8.76	578	322	0, 100, 0	3.8	0.88	0.59
301	5/14/2002	1320	96.32201	41.17878	18.4	10.33	391	316	0, 100, 0	2.1	0.72	0.64
301	5/28/2002	1730	96.33675	41.09239	25.2	17.33	486	175	0, 100, 0	8.6	0.85	-
301	6/6/2002	1245	96.21451	40.99397	24.8	12.23	861	128	0, 100, 0	3.7	0.69	0.07
301	6/13/2002	1455	96.08313	41.05531	24.1	5.35	342	1832	0, 100, 0	3.85	0.76	0.55
301	6/14/2002	1418	96.13674	41.02309	21.9	6.69	585	-	0, 100, 0	4.6	0.99	0.51
301	6/17/2002	1243	96.14473	41.0175	26.3	8.09	865	431	0, 100, 0	2.55	0.73	0.46
301	6/24/2002	1430	96.1366	41.02298	29.8	10.2	1253	129	0, 100, 0	3.05	0.72	0.64
301*	6/26/2002	759	96.13877	41.02119	26.2	6.68	894	141	0, 100, 0	4.9	0.71	-0.09
301	7/2/2002	1845	96.13715	41.02284	30	11.47	960	154	0, 100, 0	2.45	0.47	0
301	7/10/2002	1400	96.13465	41.02488	28.1	10.97	1067	143	0, 75, 25	1.25	0.57	0.49
301	7/15/2002	1854	96.13609	41.02403	31.7	11.9	1190	95	0, 90, 10	2.05	0.61	0.41
301	7/23/2002	1555	96.13668	41.02319	30.9	13.81	1482	81	0, 100, 0	1.9	0.42	0.33
301	8/1/2002	1425	96.13881	41.02113	29.5	11.95	1476	95	0, 100, 0	2.7	0.38	0.29
301	8/7/2002	1112	96.15063	41.01836	27.4	10.59	619	85	0, 90, 10	1.8	0.51	0.43
301	8/13/2002	1042	96.1926	41.00388	21.4	11.41	440	106	0, 100, 0	1.45	0.43	0.25
301	8/22/2002	1645	96.01184	41.05808	27	1.82	1392	2516	10, 90, 0	1.7	0.24	0.14
301	8/26/2002	1235	95.97405	41.05501	27	9.88	563	190	0, 90, 10	3.75	0.47	0.36
301	8/29/2002	1133	96.02109	41.06252	25.3	9.8	570	158	0, 90, 10	2.05	0.57	0.27
301*	9/3/2002	840	96.09021	41.0552	22.7	6.45	328	142	0, 100, 0	3.1	0.54	0.24
301	9/14/2002	1230	96.10705	41.05097	21.3	9.71	436	-	0, 100, 0	1.5	0.46	0.36
301	10/3/2002	1042	96.1321	41.03276	13.5	9.47	337	-	0, 100, 0	2.8	0.55	0.36
301	10/10/2002	1230	96.13483	41.0311	17.3	12.66	397	-	0, 100, 0	2.8	0.64	0.39
301	10/17/2002	1133	96.13968	41.02069	8.8	12.7	555	-	0, 100, 0	2.8	0.57	0.53

Appendix B-11. Chemical and physical habitat data collected over fish 381 from October 18, 2001 to October 17, 2002 (*12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
381	10/18/2001	1000	96.14088	41.01996	10.3	10.09	383	129	0, 100, 0	5.1	0.87	0.42
381	10/31/2001	1402	96.15953	41.01054	13.1	10.21	482	-	0, 100, 0	4.75	0.81	0.38
381	11/14/2001	1445	96.16413	41.01026	15.3	11.83	434	105	0, 100, 0	1.5	0.53	0.08
381	12/5/2001	1355	96.13933	41.02143	9.5	11.36	409	258	0, 100, 0	3.4	0.96	0.38
381	3/13/2002	1150	96.03668	41.06415	3.5	12.95	358	208	0, 100, 0	1.95	0.67	0.61
381	3/28/2002	1450	96.02116	41.06266	10.1	10.82	455	108	0, 100, 0	2.95	0.85	0.53
381	4/9/2002	1405	96.03563	41.06389	12.3	11.119	526	130	0, 100, 0	4.15	0.88	0.83
381	4/17/2002	1305	96.04936	41.06711	19.8	16.63	580	145	0, 100, 0	3.4	0.82	0.16
381	5/1/2002	1335	96.21525	40.99545	16.1	8.9	499	221	0, 100, 0	2.55	0.42	0.31
381	5/7/2002	1350	96.30935	41.03362	18.3	3.12	826	2356	0, 100, 0	5.6	1.08	0.68
381	5/20/2002	1905	96.33688	41.0977	22	9.23	456	157	0, 100, 0	2.7	0.94	0.32
381	5/28/2002	1755	96.31517	41.11143	26	11.17	454	238	0, 75, 25	2.7	0.82	-0.03
381	6/6/2002	1305	96.17096	41.00734	25.4	12.14	902	137	0, 100, 0	2.6	0.37	0.29
381	6/13/2002	1225	96.17361	41.00606	22.6	5.56	494	896	0, 100, 0	3.6	0.68	0.4
381	6/19/2002	1450	96.19997	40.99602	27.8	9.6	640	210	0, 100, 0	5.7	0.96	0.23
381	6/24/2002	1329	96.10391	41.0482	28.5	10.58	1112	154	0, 100, 0	2.1	0.62	0.18
381	7/2/2002	1855	96.10572	41.04807	30	11.46	957	136	0, 100, 0	2.05	0.48	0.41
381	7/10/2002	1412	96.12722	41.03585	28.3	12.53	577	127	0, 100, 0	3.2	0.56	0.37
381	7/15/2002	1823	96.15985	41.01153	31.5	10.4	786	109	0, 100, 0	3.6	0.68	0.43
381*	8/1/2002	1803	96.24403	41.01645	28.6	9.79	724	85	0, 100, 0	3.70	0.71	0.41
381	8/7/2002	1234	96.18674	41.0056	29	12.51	610	97	0, 100, 0	1.25	0.47	0.28
381	8/13/2002	1024	96.18676	41.00564	21.2	11.63	445	106	0, 100, 0	1.6	0.41	0.29
381	8/22/2002	1500	96.19107	41.00443	25.1	4.96	401	1732	0, 100, 0	3.95	0.67	0.09
381	8/29/2002	1155	95.96812	41.05872	25.1	9.96	667	118	0, 90, 10	1.8	0.57	0.38
381	9/3/2002	1245	95.92466	41.05938	25	9.48	379	164	0, 100, 0	1.4	0.45	0.35
381*	9/11/2002	200	95.92751	41.05861	21.8	6.76	666	-	0, 100, 0	3	0.54	0.49
381	10/17/2002	1325	95.89673	41.05927	10.2	13.9	440	-	0, 100, 0	2.5	0.35	0.18

Appendix B-12. Chemical and physical habitat data collected over fish 501 from August 29, 2000 to November 6, 2001.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
501	8/29/2000	1320	96.1385	41.0275	-	-	-	123	0, 90, 10	3.40	0.52	0.33
501	10/3/2000	1250	96.13948	41.02545	18.6	12.77	362	200	0, 100, 0	3.70	0.73	0.14
501	10/12/2000	1230	96.1389	41.0243	13.1	10.8	379	103	0, 100, 0	2.40	0.70	0.38
501	10/19/2000	1320	96.13932	41.02651	17.9	12.24	389	178	0, 100, 0	4.05	0.84	0.26
501	10/26/2000	1545	96.13923	41.02538	18.9	12.38	395	206	0, 100, 0	4.80	0.71	0.40
501	10/31/2000	1330	96.13657	41.02527	16.8	10.33	391	250	0, 100, 0	3.10	0.62	0.47
501	5/17/2001	1118	96.04472	41.06808	25	7.79	593	740	0, 50, 50	2.50	0.88	0.26
501	5/23/2001	845	96.04783	41.06405	14.5	8.22	439.8	483	0, 100, 0	4.90	0.64	0.28
501	5/29/2001	1430	96.04303	41.06453	19.9	12.64	579	168	0, 100, 0	5.30	0.15	0.25
501	6/7/2001	728	96.0318	41.0664	18.4	7.62	506	424	0, 100, 0	2.70	0.68	0.62
501	6/12/2001	1308	96.03038	41.0663	28.8	7.11	587	515	0, 100, 0	2.80	0.59	0.38
501	6/20/2001	1218	96.03683	41.1159	21.3	10.24	610	200	0, 100, 0	3.40	0.78	0.54
501	6/26/2001	1130	96.05047	41.06713	24.5	10.3	678	165	0, 100, 0	4.20	0.62	0.32
501	7/3/2001	1330	96.09612	41.05347	27.4	10.57	750	336	0, 100, 0	5.10	0.78	-0.07
501	7/10/2001	1240	96.134	41.029	28	7.89	979	189	0, 100, 0	1.05	0.59	0.53
501	7/17/2001	1200	96.15428	41.01498	29.1	11.34	852	164	0, 100, 0	1.65	0.52	0.37
501	7/26/2001	1000	96.14999	41.01721	24.1	5.89	904	122	0, 100, 0	2.65	0.72	0.61
501	8/2/2001	1100	96.1825	41.00538	30.2	6.8	821	142	0, 100, 0	1.65	0.51	0.38
501	8/7/2001	1215	96.19538	41.00241	30.4	8.51	657	-	0, 75, 25	2.20	0.28	0.05
501	10/31/2001	1327	96.13464	41.02588	12.9	10.2	397	83	0, 100, 0	2.25	0.51	0.43
501	11/6/2001	1230	96.11185	41.04381	15	10.62	697	72	0, 100, 0	4.80	0.74	0.52

Appendix B-13. Chemical and physical habitat data collected over fish 521 from May 24, 2001 to April 4, 2002.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
521	5/24/2001	1310	96.15453	41.01595	13.5	10.02	502	282	0, 100, 0	5.50	1.02	0.54
521	6/1/2001	1018	96.14237	41.01823	16	8.04	387.5	867	0, 100, 0	4.70	0.77	0.49
521	6/5/2001	1150	96.14187	41.01823	16	9.07	600	205	0, 100, 0	10.50	0.57	-
521	6/12/2001	1448	96.14167	41.01845	29.4	9.41	699	276	0, 100, 0	9.60	0.99	-
521	6/20/2001	1130	96.1602	41.01217	21.4	10.29	546	200	0, 100, 0	2.70	0.54	0.09
521	6/21/2001	1615	96.1476	41.01833	25.5	9.83	752	192	0, 100, 0	1.80	0.67	0.47
521	6/26/2001	1217	96.1447	41.01788	24.8	11.09	794	126	0, 100, 0	7.00	0.72	0.59
521	7/3/2001	1100	96.15447	41.01391	25.1	9.68	726	275	0, 100, 0	1.70	0.31	0.17
521	7/17/2001	1230	96.04345	41.06757	29.2	11.49	733	200	0, 90, 10	1.60	0.54	0.37
521	7/26/2001	1030	96.04131	41.06780	24.3	6.4	717	157	0, 100, 0	3.30	0.52	0.31
521	7/31/2001	1515	96.04343	41.06741	32.2	5.26	717	176	0, 50, 50	1.50	0.77	0.42
521	8/7/2001	944	96.04803	41.06774	28.5	-	821	117	0, 90, 10	3.00	0.67	0.48
521	8/16/2001	2015	96.05650	41.06692	25.9	11.79	1012	150	0, 100, 0	3.70	0.41	0.26
521	8/24/2001	1040	96.06993	41.06013	25.9	8.81	992	90	0, 100, 0	2.10	0.32	0.21
521	8/30/2001	1055	96.06950	41.06014	24.5	8.94	857	100	0, 100, 0	2.15	0.31	0.19
521	9/5/2001	1500	96.04479	41.06746	27.4	12.08	828	-	0, 100, 0	2.30	0.59	0.55
521	9/11/2001	1000	96.04316	41.06743	19.5	9.43	504	-	0, 100, 0	1.75	0.47	0.34
521	9/20/2001	1040	96.09676	41.05194	19.7	8.66	596	149	0, 100, 0	1.90	0.50	0.38
521	10/4/2001	1000	96.21184	40.99500	16	8.24	439	-	0, 100, 0	1.70	0.56	0.43
521	10/15/2001	1040	96.23045	41.00170	11	9.58	350	-	0, 100, 0	3.60	0.49	0.17
521	11/1/2001	1130	96.24645	41.01740	14.2	9.99	419	71	0, 100, 0	3.00	0.53	0.11
521	11/7/2001	1037	96.24577	41.01741	14.5	11.42	411	112	0, 100, 0	2.40	0.72	0.41
521	12/5/2001	1325	96.24334	41.01553	9.2	11.21	374	266	0, 100, 0	3.90	0.47	0.23
521	3/12/2002	1350	96.2381	41.00586	3.8	12.01	647	39	0, 100, 0	2.4	0.37	0.27
521	4/4/2002	1454	96.23692	41.00529	8.3	12.52	533	117	0, 100, 0	4.3	0.73	0.42

Appendix B-14. Chemical and physical habitat data collected over fish 641 from August 22, 2000 to October 18, 2001.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
641	8/22/2000	915	95.974	41.05550	-	-	-	122	0, 100, 0	4.10	0.35	0.16
641	9/28/2000	1240	95.97645	41.05315	17.9	13.18	702	184	0, 100, 0	4.80	0.77	0.4
641	10/3/2000	1050	95.97673	41.05347	17.4	11.93	786	100	0, 100, 0	3.60	0.77	0.62
641	10/12/2000	1045	95.9747	41.05423	11.6	10.8	450	100	0, 100, 0	3.80	0.92	0.53
641	10/17/2000	1150	95.9741	41.05398	16.5	12.12	663	153	0, 100, 0	8.20	0.69	0.6
641	10/31/2000	1120	95.97963	41.05187	15.5	9.59	497	-	0, 100, 0	5.85	0.49	0.27
641	5/23/2001	1100	96.34062	41.08838	13.9	10.07	418.6	195	0, 100, 0	3.30	0.56	0.39
641	6/1/2001	1315	96.36265	41.22905	20.2	12.71	398.7	133	0, 100, 0	2.10	0.39	0.12
641	6/4/2001	1345	96.37498	41.29448	16.0	10.65	368.4	126	0, 100, 0	1.85	0.65	0.54
641	6/6/2001	1150	96.40168	41.31362	17.3	12.28	385	122	0, 100, 0	3.50	0.73	0.59
641	6/13/2001	1546	96.44957	41.37345	27.9	10.02	489.3	95	0, 100, 0	4.90	0.94	0.46
641	6/21/2001	1315	96.57873	41.43447	23.1	13.29	543	145	0, 100, 0	2.10	0.51	-0.02
641	6/27/2001	1000	96.59107	41.43625	23.1	10.06	373	57	0, 100, 0	2.65	0.63	0.51
641	7/5/2001	945	96.55822	41.43477	24.0	9.19	511	51	0, 100, 0	2.65	0.57	-0.04
641	7/12/2001	1135	96.43705	41.36633	23.8	9.73	418	46	0, 25, 75	1.50	0.55	0.41
641	7/17/2001	900	96.26427	41.01743	26.9	8.28	1130	152	0, 100, 0	2.00	0.57	0.34
641	7/31/2001	1612	95.94748	41.05700	32.3	9.44	763	150	0, 75, 25	3.10	0.76	0.26
641	8/7/2001	1035	95.95226	41.06021	29.1	-	858	119	0, 100, 0	3.10	0.6	0.43
641	8/16/2001	1755	95.96843	41.05816	25.9	13.51	1097	-	0, 100, 0	4.10	0.59	0.31
641	8/24/2001	1130	95.97643	41.05381	26.2	9.24	842	168	0, 100, 0	3.25	0.77	0.35
641	8/30/2001	1145	95.97847	41.05260	24.9	9.29	744	136	0, 90, 10	2.95	0.71	0.48
641	9/20/2001	1140	95.97737	41.05322	20.0	8.81	556	-	0, 100, 0	4.85	1.09	0.23
641	10/18/2001	1115	95.97531	41.05404	10.6	10.29	592	109	0, 100, 0	4.80	0.68	0.54

Appendix B-15. Chemical and physical habitat data collected over fish 661 from October 15, 2001 to May 20, 2002.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
661	10/15/2001	1105	96.25053	41.01735	10.8	9.97	304	190	0, 100, 0	3.35	0.54	0.28
661	11/1/2001	1100	96.24915	41.01711	13.7	9.64	407.4	65	0, 100, 0	1.85	0.35	0.23
661	11/5/2001	1630	96.25001	41.01757	14.9	11.62	412	98	0, 100, 0	3.65	0.72	0.16
661	12/5/2001	1215	96.23991	41.01015	9.2	11.56	298	229	0, 100, 0	3.75	0.72	0.56
661	3/13/2002	1125	96.08886	41.05317	3.2	13.03	396	240	0, 100, 0	4.2	0.52	0.22
661	3/28/2002	1427	96.08729	41.05343	10.4	10.65	523	111	0, 100, 0	2.1	0.29	0.17
661	4/17/2002	1250	96.08749	41.0556	19.7	16.48	590	133	0, 100, 0	2.3	0.42	0.27
661	5/1/2002	1233	96.12051	41.03942	15.9	9.6	496	349	0, 100, 0	3.1	0.24	0.16
661	5/7/2002	1230	96.11654	41.04097	19	9.71	536	602	0, 100, 0	2.2	0.56	0.34
661	5/13/2002	1330	96.12762	41.03284	14.5	8.73	403	1624	0, 100, 0	2.8	0.56	-0.03
661	5/20/2002	1715	96.1908	41.00357	21.1	10.97	539	235	0, 100, 0	2.2	0.45	0.29

Appendix B-16. Chemical and physical habitat data collected over fish 821 from May 7, 2002 to September 11, 2002 (12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
821	5/7/2002	1210	96.14776	41.01723	18.7	7.77	670	602	0, 100, 0	2.1	0.73	0.32
821	5/13/2002	1315	96.14718	41.01655	14.3	8.98	370	297	0, 100, 0	1.4	0.4	0.13
821	5/20/2002	1620	96.27583	41.02042	21.1	10.98	571	186	0, 100, 0	2.3	0.54	0.34
821	5/30/2002	1435	96.23311	40.99895	27.3	8.02	638	555	0, 100, 0	3.05	0.54	0.38
821*	7/15/2002	2155	95.89021	41.05744	29.6	7.62	1033	128	0, 100, 0	4.9	0.93	-0.03
821*	9/11/2002	345	95.92415	41.05907	21.1	6.75	734	-	0, 90, 10	1.75	0.37	0.23

Appendix B-17. Chemical and physical habitat data collected over fish 841 from May 13, 2002 to June 17, 2002 (*12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
841	5/13/2002	1235	96.00764	41.06141	14	9.14	441	1054	0, 100, 0	3.7	0.66	0.39
841*	5/29/2002	207	95.99934	41.05782	22.5	6.19	548	2060	0, 100, 0	2.25	0.54	0.39
841	6/5/2002	1520	95.99794	41.05835	24.3	12.96	634	127	0, 100, 0	1.4	0.65	0.56
841	6/11/2002	1425	95.99703	41.05817	27.2	12.3	608	248	0, 100, 0	4.9	0.59	0.23
841	6/17/2002	1447	95.99635	41.05798	25.7	10.01	553	832	0, 100, 0	6.2	0.78	0.71

Appendix B-18. Chemical and physical habitat data collected over fish 621 (pallid sturgeon) from May 4, 2001 to June 7, 2001.

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
621	5/4/2001	1120	96.15297	41.01658	14.8	8.74	410.1	876	0, 100, 0	5.9	1.28	0.84
621	5/6/2001	1430	96.14752	41.01693	18.2	7.54	386.4	1208	0, 100, 0	4.7	0.67	0.51
621	5/9/2001	1320	96.14292	41.02002	19.1	8.12	446.1	1228	0, 100, 0	3.9	0.62	0.43
621	5/14/2001	1430	96.13875	41.02342	24	8.41	522	466	0, 100, 0	4.5	0.65	0.49
621	5/15/2001	1357	96.13927	41.02687	24.9	8.75	549	432	0, 100, 0	2.5	0.98	0.7
621	5/17/2001	1218	96.13885	41.02643	24.7	8.19	607	838	-	-	-	-
621	5/22/2001	1300	96.13777	41.02785	15.8	12.22	435	574	0, 100, 0	3.6	0.81	0.7
621	5/24/2001	1230	96.1364	41.0293	13.2	9.65	475	270	0, 100, 0	5.5	0.93	0.63
621	6/1/2001	940	96.1158	41.04108	16.1	8.80	426.7	503	0, 100, 0	2.95	0.79	0.68
621	6/5/2001	1317	96.03158	41.06477	16.8	9.82	570	198	0, 100, 0	3	1.01	0.82
621	6/7/2001	805	95.98585	41.0527	18.5	7.80	542	445	0, 100, 0	1.9	0.89	0.77

Appendix B-19. Chemical and physical habitat data collected over fish 721 (pallid sturgeon) from May 28, 2002 to May 29, 2002 (*12-hour survey).

Fish	Date	Time	GPS WGS-84(x)	GPS WGS-84(y)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS)	Total Suspended Solids (mg/L)	Substrate (%silt, %sand, %gravel)	Depth (ft)	MCV (m/s)	BV (m/s)
721	5/28/2002	1955	96.01481	41.05904	25.5	8.42	661	594	0, 100, 0	2.4	0.58	0.37
721	5/28/2002	2200	96.01544	41.06003	24.4	8.83	580	577	0, 100, 0	5	0.96	0.28
721	5/28/2002	2350	96.01883	41.06048	22.9	5.81	584	2576	0, 100, 0	8.9	1.03	-
721	5/29/2002	147	96.01105	41.05933	22.5	6.16	568	1568	0, 100, 0	2.95	0.58	0.51
721	5/29/2002	330	95.99155	41.05538	23.1	7.22	475	750	0, 100, 0	5.8	0.97	0.48
721	5/29/2002	555	95.99031	41.05493	22.8	6.89	456	668	0, 100, 0	4.45	1.14	0.62
721	5/29/2002	750	95.99099	41.05469	22	6.71	492	1172	0, 100, 0	4.45	0.68	0.52

Appendix C-1 Physical habitat data surrounding fish 21/341from July 20, 2000 to May 8, 2002.

Date	Substrate (%silt, %sand, %gravel) at 2	Dept h (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
7/20/2000	0, 100, 0	5	0.34	0.28	0, 100, 0	9	0.46	0.12	0, 100, 0	5.7	0.38	0.19	0, 100, 0	7	0.28	0.03
7/28/2000	0, 100, 0	0.8	0.42	0.32	0, 100, 0	0.8	0.41	0.33	0, 100, 0	0.7	0.48	0.38	0, 100, 0	0.8	0.45	0.39
8/11/2000	0, 100, 0	0.9	0.61	0.56	0, 100, 0	0.8	0.51	0.48	0, 100, 0	1	0.54	0.14	0, 100, 0	1.3	0.72	0.6
8/22/2000	0, 100, 0	1.8	0.63	0.51	0, 100, 0	1.8	0.46	0.18	0, 100, 0	2.5	0.51	0.13	0, 100, 0	2.4	0.53	0.19
8/29/2000	0, 100, 0	2	0.52	0.26	0, 100, 0	1.9	0.51	0.38	0, 100, 0	1.5	0.54	0.22	0, 100, 0	1.5	0.54	0.23
9/21/2000	0, 100, 0	6	0.7	0.36	0, 100, 0	4.9	0.93	0.62	0, 100, 0	3.5	0.8	0.59	0, 100, 0	5.6	0.96	0.37
10/12/2000	0, 100, 0	1.9	0.66	0.24	0, 100, 0	1.4	0.78	0.23	0, 100, 0	0.76	0.57	0	0, 100, 0	1.8	0.53	0.48
10/31/2000	0, 100, 0	6.7	0.74	-0.03	0, 100, 0	3.5	1.04	0.69	0, 100, 0	3.4	0.69	0.44	0, 100, 0	4.5	0.84	-0.03
6/12/2001	0, 90, 10	2.1	0.41	0.34	0, 75, 25	2	0.45	0.35	0, 50, 50	1.5	0.35	0.26	0, 85, 15	1.8	0.36	0.26
6/20/2001	0, 100, 0	5	0.41	0.27	0, 100, 0	5.1	0.39	0.21	0, 100, 0	4.9	0.36	0.17	0, 100, 0	5.25	0.41	0.19
6/26/2001	0, 100, 0	2.5	0.55	0.41	0, 100, 0	1.8	0.5	0.31	0, 90, 10	1.4	0.56	0.51	0, 100, 0	1.5	0.48	0.35
7/3/2001	0, 50, 50	1.35	0.53	0.44	0, 50, 50	1.5	0.59	0.49	0, 75, 25	1.5	0.52	0.38	0, 75, 25	1.3	0.55	0.42
7/10/2001	0, 100, 0	1.3	0.39	0.34	0, 100, 0	1.45	0.43	0.37	0, 100, 0	2	0.51	0.26	0, 100, 0	1.45	0.49	0.37
7/17/2001	0, 100, 0	2.7	0.98	0.85	0, 100, 0	3.55	0.89	0.29	0, 100, 0	3.6	0.82	0.58	0, 100, 0	4	0.82	0.3
7/26/2001	0, 100, 0	3.4	0.72	0.37	0, 100, 0	2.4	0.59	0.26	0, 100, 0	2.6	0.54	0.44	0, 100, 0	2.5	0.61	0.34
7/31/2001	0, 50, 50	1.2	0.65	0.31	0, 50, 50	1.3	0.63	0.57	0, 90, 10	1.65	0.55	0.34	0, 75, 25	1.3	0.77	0.51
8/7/2001	0, 25, 75	1.4	0.51	0.39	0, 100, 0	2.4	0.55	0.38	0, 100, 0	2.4	0.62	0.45	0, 100, 0	3	0.63	0.41
8/16/2001	0, 100, 0	1.8	0.36	0.12	0, 100, 0	1.6	0.25	0.19	0, 100, 0	1	0.27	0.14	0, 100, 0	1.5	0.21	0.11
8/24/2001	0, 100, 0	1.75	0.48	0.34	0, 100, 0	1.6	0.37	0.24	0, 100, 0	1.4	0.48	0.37	0, 100, 0	1.8	0.54	0.39
8/30/2001	0, 100, 0	2.2	0.55	0.37	0, 100, 0	2.15	0.58	0.43	0, 100, 0	2.2	0.47	0.25	0, 100, 0	2.2	0.65	0.45
9/5/2001	0, 25, 75	1.6	0.65	0.49	0, 100, 0	2.1	0.52	0.35	0, 75, 25	1.85	0.57	0.38	0, 100, 0	2.15	0.58	0.45
9/8/2001	0, 30, 70	1.1	0.67	0.5	0, 30, 70	1.4	0.53	0.45	0, 30, 70	1.7	0.68	0.43	0, 30, 70	1.3	0.66	0.5
9/11/2001	0, 100, 0	3.85	0.54	0.31	0, 100, 0	3.25	0.57	0.34	0, 100, 0	2.65	0.41	0.26	0, 100, 0	2.95	0.48	0.32
9/20/2001	0, 100, 0	3.25	0.61	0.43	0, 100, 0	2.9	0.69	0.55	0, 50, 50	3.15	0.58	0.24	0, 100, 0	2.7	0.84	0.68
9/26/2001	0, 100, 0	1.3	0.48	0.38	0, 100, 0	1.1	0.51	0.45	0, 100, 0	1.2	0.46	0.31	0, 100, 0	1.4	0.49	0.37
10/10/2001	0, 100, 0	1.65	0.61	0.47	0, 100, 0	1.75	0.53	0.35	0, 100, 0	1.85	0.54	0.02	0, 100, 0	1.75	0.53	0.31
10/18/2001	0, 100, 0	1.75	0.18	-0.12	0, 100, 0	1.25	0.61	0.42	0, 100, 0	2	0.44	-0.04	0, 100, 0	2.1	0.64	-0.13
10/31/2001	0, 100, 0	5.6	1.04	0.59	0, 100, 0	5.8	0.9	0.34	0, 100, 0	4.6	0.94	0.58	0, 100, 0	5.35	0.87	0.48

Appendix C-1. Continued.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
11/6/2001	0, 90, 10	2.5	0.61	0.23	0, 90, 10	2	0.56	0.48	0, 100, 0	2.65	0.54	0.45	0, 100, 0	3.45	0.63	-0.02
11/15/2001	0, 75, 25	2.7	0.55	0.03	0, 50, 50	2.05	0.58	0.51	0, 75, 25	2.7	0.55	-0.07	0, 75, 25	2.1	0.59	0.34
3/13/2002	0, 100, 0	8.8	0.64	-	0, 100, 0	8.4	0.79	-	0, 100, 0	8.6	0.76	-	0, 100, 0	8.2	0.82	-
3/28/2002	0, 100, 0	2.8	0.64	0.56	0, 100, 0	3.05	0.68	0.47	0, 100, 0	3.7	0.67	0.42	0, 100, 0	3.35	0.68	0.58
4/9/2002	0, 100, 0	2.6	0.44	0.38	0, 100, 0	2.5	0.58	0.46	0, 100, 0	2.9	0.56	0.14	0, 100, 0	3	0.51	0.23
4/17/2002	0, 100, 0	3.8	0.76	0.42	0, 100, 0	3.4	0.86	0.46	0, 100, 0	3.25	0.97	0.74	0, 100, 0	4.1	0.66	0.35
5/8/2002	0, 100, 0	3.8	0.82	0.27	0, 100, 0	3.45	0.98	0.59	0, 100, 0	4.25	0.86	0.19	0, 100, 0	5	0.74	-0.07

Appendix C-2. Physical habitat data surrounding fish 81 from August 22, 2000 to November 15, 2001.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
8/22/2000	0, 100, 0	4.60	0.67	0.35	0, 100, 0	4.30	0.65	0.36	0, 100, 0	3.60	0.71	0.48	0, 100, 0	4.40	0.65	0.38
8/29/2000	0, 100, 0	4.80	0.75	0.29	0, 100, 0	3.50	0.76	0.43	0, 100, 0	3.30	0.64	0.28	0, 100, 0	3.10	0.74	0.30
9/12/2000	0, 90, 10	3.65	0.42	0.11	0, 90, 10	3.60	0.40	0.27	0, 90, 10	2.95	0.18	0.13	0, 90, 10	3.70	0.29	0.18
9/28/2000	0, 100, 0	2.00	0.55	0.46	0, 100, 0	2.40	0.72	0.32	0, 100, 0	2.10	0.74	0.31	0, 100, 0	1.90	0.71	0.05
10/12/2000	0, 100, 0	2.50	0.55	0.31	0, 100, 0	2.30	0.85	0.69	0, 100, 0	2.50	0.70	0.11	0, 100, 0	2.60	0.72	0.08
10/17/2000	0, 80, 20	2.15	0.01	0.03	0, 80, 20	2.60	0.03	0.04	0, 80, 20	1.80	0.45	0.33	0, 80, 20	2.00	0.30	-0.03
10/31/2000	0, 100, 0	1.20	0.37	0.28	0, 100, 0	1.30	0.32	0.2	0, 100, 0	0.80	0.23	0.23	0, 100, 0	0.80	0.36	0.30
5/29/2001	0, 100, 0	3.40	1.12	0.56	0, 100, 0	3.30	1.26	0.51	0, 100, 0	4.00	1.07	0.52	0, 100, 0	3.60	0.97	0.54
6/12/2001	0, 100, 0	9.00	0.73	0.45	0, 100, 0	7.70	0.75	0.54	0, 100, 0	5.30	0.72	0.60	0, 100, 0	7.40	0.48	0.50
6/20/2001	0, 100, 0	3.05	0.43	0.23	0, 100, 0	3.05	0.44	0.29	0, 100, 0	4.00	0.30	0.24	0, 100, 0	3.40	0.41	0.24
6/26/2001	0, 100, 0	6.10	0.71	0.37	0, 100, 0	5.30	0.62	0.44	0, 100, 0	4.25	0.58	0.33	0, 100, 0	5.35	0.64	0.42
7/3/2001	0, 100, 0	2.60	0.47	0.34	0, 100, 0	2.25	0.51	0.35	0, 100, 0	2.25	0.61	0.42	0, 100, 0	2.20	0.52	0.31
7/10/2001	0, 100, 0	4.10	0.59	0.51	0, 100, 0	4.00	0.58	0.39	0, 100, 0	2.85	0.38	0.29	0, 100, 0	4.30	0.53	0.23
7/17/2001	0, 100, 0	2.90	0.55	0.42	0, 100, 0	3.20	0.63	0.50	0, 100, 0	3.45	0.69	0.48	0, 100, 0	3.30	0.59	0.19
7/26/2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/31/2001	0, 100, 0	8.70	0.92	0.54	0, 100, 0	7.90	0.81	0.48	0, 100, 0	6.80	0.86	0.70	0, 100, 0	7.80	1.26	0.40
8/7/2001	0, 100, 0	3.80	0.68	0.45	0, 100, 0	3.75	0.68	0.48	0, 100, 0	3.30	0.74	0.44	0, 100, 0	3.45	0.71	0.46
8/16/2001	0, 100, 0	2.10	0.22	0.13	0, 100, 0	2.10	0.30	0.03	0, 100, 0	1.90	0.21	0.16	0, 100, 0	2.20	0.18	0.07
8/24/2001	0, 100, 0	2.45	0.41	0.27	0, 100, 0	2.40	0.40	0.23	0, 100, 0	1.60	0.57	-0.07	0, 100, 0	2.30	0.39	0.26
8/30/2001	0, 100, 0	2.00	0.26	0.24	0, 100, 0	2.00	0.26	0.18	0, 100, 0	2.00	0.30	0.21	0, 100, 0	2.30	0.43	0.18
9/11/2001	0, 100, 0	3.75	0.64	0.16	0, 100, 0	3.90	0.68	0.32	0, 100, 0	4.10	0.70	0.33	0, 100, 0	3.90	0.59	0.45
10/10/2001	0, 100, 0	3.65	0.78	0.42	0, 100, 0	3.30	0.72	0.49	0, 100, 0	2.30	0.57	0.42	0, 100, 0	3.45	0.74	0.38
10/18/2001	0, 100, 0	2.60	0.57	0.39	0, 100, 0	3.00	0.75	0.06	0, 100, 0	2.95	0.49	0.19	0, 100, 0	2.60	0.66	0.22
10/31/2001	0, 100, 0	5.05	0.49	0.28	0, 100, 0	5.20	0.48	0.16	0, 100, 0	4.90	0.41	0.25	0, 100, 0	5.00	0.51	0.29
11/15/2001	0, 100, 0	4.45	0.49	-0.05	0, 100, 0	3.80	0.72	0.48	0, 100, 0	3.90	0.55	0.49	0, 100, 0	3.60	0.77	0.42

Appendix C-3. Physical habitat data surrounding fish 101/111 from August 11, 2000 to June 19, 2002.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MC V (m/s) at 5	BV (m/s) at 5
8/11/2000	0, 100, 0	2.40	0.63	0.4	0, 100, 0	3.10	0.55	0.30	0, 100, 0	2.70	0.64	0.44	0, 100, 0	3.00	0.56	- 0.09
8/18/2000	0, 100, 0	2.20	0.85	-0.05	0, 100, 0	2.10	0.60	0.21	0, 100, 0	1.90	0.60	0.43	0, 100, 0	2.50	0.50	0.23
8/31/2000	10, 90, 0	1.00	0.29	0.16	10, 90, 0	1.30	0.54	0.25	10, 90, 0	0.90	0.35	0.30	10, 90, 0	1.20	0.48	0.40
9/12/2000	0, 100, 0	1.00	0.51	0.49	0, 100, 0	1.15	0.56	0.45	0, 100, 0	1.50	0.49	0.42	0, 100, 0	1.20	0.45	0.26
9/21/2000	0, 100, 0	1.00	0.38	0.3	0, 100, 0	0.90	0.68	0.65	0, 100, 0	1.50	0.73	0.61	0, 100, 0	1.10	0.35	0.32
10/3/2000	0, 100, 0	2.45	0.39	0.25	0, 100, 0	2.50	0.44	0.31	0, 100, 0	2.00	0.50	0.34	0, 100, 0	2.50	0.48	0.24
10/12/2000	0, 100, 0	1.70	0.47	0.17	0, 100, 0	1.50	0.45	0.32	0, 100, 0	1.10	0.38	0.22	0, 100, 0	1.40	0.35	0.29
10/26/2000	0, 100, 0	2.30	0.59	0.4	0, 100, 0	1.70	0.67	0.61	0, 100, 0	2.40	0.49	0.35	0, 100, 0	2.30	0.62	0.37
5/18/2001	0, 80, 20	1.90	0.54	0.39	0, 80, 20	1.90	0.56	0.34	0, 80, 20	1.90	0.58	0.43	0, 90, 10	1.85	0.52	0.41
5/31/2001	0, 100, 0	3.00	0.84	0.11	0, 100, 0	4.30	0.73	0.30	0, 100, 0	3.45	0.73	0.23	0, 100, 0	3.00	0.84	0.73
6/6/2001	0, 95, 5	1.20	0.74	0.81	0, 85, 15	1.40	0.75	0.63	0, 95, 5	1.70	0.71	0.36	0, 50, 50	1.70	0.75	0.01
6/13/2001	0, 50, 50	2.05	0.68	0.54	0, 80, 20	1.70	0.71	0.48	0, 95, 5	1.60	0.76	0.64	0, 25, 75	1.70	0.71	0.38
6/21/2001	0, 100, 0	5.40	0.83	0.58	0, 100, 0	6.20	0.76	0.28	0, 100, 0	6.20	0.76	0.52	0, 100, 0	6.20	0.79	0.23
6/26/2001	0, 100, 0	1.70	0.44	0.36	0, 100, 0	3.20	0.59	0.55	0, 100, 0	2.10	0.52	0.41	0, 100, 0	2.20	0.55	0.42
7/3/2001	0, 85, 15	1.50	0.58	0.49	0, 60, 40	1.60	0.59	0.38	0, 25, 75	1.85	0.58	0.43	0, 50, 50	1.75	0.54	0.42
7/11/2001	0, 100, 0	2.30	0.66	0.56	0, 100, 0	3.10	0.49	0.19	0, 100, 0	1.45	0.56	0.49	0, 100, 0	2.25	0.66	0.57
7/17/2001	0, 100, 0	2.15	0.52	0.24	0, 100, 0	1.95	0.55	0.34	0, 100, 0	1.30	0.46	0.38	0, 100, 0	1.60	0.56	0.26
7/25/2001	0, 100, 0	3.20	0.73	0.43	0, 100, 0	2.50	0.76	0.57	0, 100, 0	2.75	0.71	0.65	0, 100, 0	2.60	0.54	0.41
8/2/2001	0, 100, 0	2.95	0.59	0.39	0, 100, 0	2.80	0.56	0.38	0, 100, 0	1.80	0.46	0.32	0, 75, 25	2.60	0.62	0.41
8/7/2001	0, 100, 0	1.45	0.45	0.32	0, 100, 0	1.30	0.44	0.42	0, 100, 0	1.50	0.47	0.42	0, 100, 0	1.20	0.27	0.16
8/14/2001	0, 100, 0	1.60	0.31	0.2	0, 100, 0	1.50	0.30	0.21	0, 100, 0	1.50	0.31	0.13	0, 100, 0	1.50	0.29	0.17
8/23/2001	0, 90, 10	3.80	0.63	0.16	0, 100, 0	3.90	0.73	0.50	0, 100, 0	3.60	0.56	0.42	0, 100, 0	4.10	0.67	0.25
8/30/2001	0, 100, 0	1.15	0.28	0.28	0, 100, 0	1.45	0.37	0.29	0, 100, 0	1.40	0.35	0.28	0, 100, 0	1.50	0.26	0.19
9/5/2001	0, 90, 10	1.65	0.42	0.37	0, 75, 25	1.45	0.49	0.43	0, 75, 25	1.30	0.45	0.38	0, 50, 50	1.80	0.49	0.09
9/12/2001	-	-	-	-	-	-	-	-	-	-	-	-	-			
9/19/2001	0, 100, 0	2.35	0.51	0.38	0, 100, 0	3.40	0.57	0.38	0, 100, 0	4.30	0.56	0.36	0, 100, 0	3.15	0.48	0.38
9/29/2001	0, 100, 0	1.90	0.37	0.28	0, 90, 10	2.05	0.36	0.16	0, 100, 0	1.90	0.51	0.38	0, 90, 10	1.90	0.41	0.32

Appendix C-3. Continued

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
10/15/2001	0, 100, 0	2.10	0.51	0.25	0, 100, 0	2.50	0.59	0.44	0, 100, 0	2.80	0.68	0.48	0, 100, 0	2.40	0.59	0.29
11/1/2001	0, 90, 10	2.40	0.39	0.22	0, 100, 0	2.70	0.41	0.27	0, 100, 0	2.90	0.45	0.25	0, 100, 0	2.65	0.39	0.26
11/7/2001	0, 100, 0	3.90	0.69	0.34	0, 100, 0	3.60	0.48	0.29	0, 100, 0	3.05	0.39	0.26	0, 100, 0	3.70	0.52	0.36
12/5/2001	0, 75, 25	1.95	0.36	0.19	0, 100, 0	2.05	0.41	0.12	0, 100, 0	2.15	0.51	0.44	0, 100, 0	1.70	0.36	0.20
3/12/2002	0, 100, 0	3.05	0.74	0.72	0, 100, 0	3.4	0.76	0.43	0, 100, 0	4.1	0.74	0.62	0, 100, 0	4.35	0.71	0.17
4/4/2002	0, 100, 0	3.95	0.15	0.1	0, 100, 0	4.3	0.53	0.36	0, 100, 0	4.6	0.59	0.37	0, 100, 0	3	0.4	0.29
4/18/2002	0, 100, 0	7.4	1.05	0.12	0, 100, 0	6.4	0.98	0.56	0, 100, 0	5.85	1.04	-0.03	0, 100, 0	5.9	1.13	0.64
5/2/2002	0, 100, 0	2.8	0.89	0.28	0, 100, 0	2.9	0.9	-0.03	0, 100, 0	2.8	0.92	0.46	0, 100, 0	3	0.75	0.66
5/7/2002	0, 100, 0	2.7	0.37	0.22	0, 100, 0	3.2	0.33	0.15	0, 100, 0	3.1	0.37	0.21	0, 100, 0	2.85	0.32	0.13
5/14/2002	0, 100, 0	2.45	0.63	0.57	0, 100, 0	2.8	0.64	0.51	0, 100, 0	2.3	0.73	0.55	0, 100, 0	2.6	0.58	0.35
5/20/2002	0, 100, 0	1.35	0.77	0.51	0, 100, 0	1.6	0.71	0.62	0, 100, 0	1.8	0.66	0.58	0, 100, 0	1.9	0.63	0.52
6/6/2002	0, 100, 0	3.15	0.44	0.32	0, 100, 0	2.65	0.43	0.33	0, 100, 0	1.4	0.37	0.19	0, 100, 0	2.75	0.39	0.27
6/19/2002	0, 100, 0	1.8	0.35	0.04	0, 100, 0	1.65	0.37	0.08	0, 100, 0	1.9	0.43	0.24	0, 100, 0	2.05	0.46	0.2

Appendix C-4. Physical habitat data surrounding fish 121 from August 22, 2000 to September 11, 2001.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
8/22/2000	0, 60, 40	2.40	0.63	0.48	0, 60, 40	2.30	0.73	0.02	0, 60, 40	2.30	0.71	0.62	0, 60, 40	2.50	0.71	0.48
8/29/2000	0, 30, 70	1.90	0.55	0.29	0, 30, 70	2.10	0.72	0.59	0, 30, 70	1.90	0.65	0.20	0, 30, 70	2.00	0.39	0.31
9/12/2000	0, 95, 5	2.10	0.52	0.41	0, 95, 5	2.15	0.66	0.51	0, 95, 5	2.10	0.66	0.56	0, 95, 5	1.95	0.75	0.58
9/21/2000	0, 100, 0	0.90	0.62	0.28	0, 100, 0	2.70	0.60	0.37	0, 100, 0	2.70	0.71	0.54	0, 100, 0	2.40	0.45	0.29
10/31/2000	0, 100, 0	4.80	0.64	0.2	0, 100, 0	3.50	0.75	0.51	0, 100, 0	3.20	0.8	0.22	0, 100, 0	3.50	0.76	0.44
5/18/2001	0, 60, 40	1.60	0.68	0.53	0, 60, 40	1.50	0.51	0.42	0, 50, 50	1.50	0.51	0.42	0, 95, 5	1.60	0.63	0.54
5/31/2001	0, 100, 0	3.00	0.64	0.24	0, 100, 0	2.60	0.63	0.20	0, 100, 0	1.40	0.65	0.51	0, 100, 0	2.40	0.69	0.54
6/6/2001	0, 100, 0	3.00	0.87	0.52	0, 100, 0	3.70	0.72	0.32	0, 100, 0	3.90	0.62	0.52	0, 100, 0	3.70	0.60	0.49
6/13/2001	0, 100, 0	1.50	0.49	0.38	0, 50, 50	1.90	0.72	0.29	0, 85, 15	2.40	0.76	0.31	0, 95, 5	1.80	0.82	0.39
6/21/2001	0, 100, 0	1.40	0.54	0.26	0, 100, 0	2.30	0.49	0.07	0, 90, 10	2.30	0.59	0.41	0, 100, 0	1.80	0.58	0.29
6/27/2001	0, 100, 0	3.10	0.61	0.48	0, 100, 0	3.60	0.74	0.42	0, 100, 0	3.75	0.81	0.08	0, 100, 0	3.50	0.62	0.24
7/5/2001	0, 75, 25	1.80	0.62	0.51	0, 50, 50	1.90	0.66	0.32	0, 50, 50	1.60	0.77	0.63	0, 50, 50	2.10	0.77	0.44
7/12/2001	0, 100, 0	1.50	0.27	0.19	0, 75, 25	1.70	0.46	0.34	0, 90, 10	1.90	0.44	0.32	0, 90, 10	1.50	0.25	0.22
7/17/2001	0, 50, 50	3.55	0.70	0.47	0, 50, 50	3.30	0.54	0.43	0, 100, 0	1.85	0.46	0.42	0, 100, 0	3.50	0.44	-0.01
7/25/2001	0, 100, 0	1.50	0.36	0.27	0, 100, 0	1.15	0.33	0.20	0, 100, 0	0.95	0.29	0.22	0, 100, 0	1.20	0.28	0.24
8/2/2001	0, 100, 0	1.10	0.31	0.28	0, 100, 0	1.40	0.44	0.22	0, 100, 0	1.30	0.38	0.11	0, 100, 0	1.10	0.51	0.44
8/7/2001	0, 100, 0	2.15	0.21	0.11	0, 100, 0	2.60	0.58	0.32	0, 100, 0	2.00	0.73	0.32	0, 100, 0	2.90	0.42	0.31
8/14/2001	0, 100, 0	1.25	0.50	0.36	0, 100, 0	3.55	0.41	0.33	0, 100, 0	2.75	0.32	0.25	0, 100, 0	2.30	0.33	0.24
8/23/2001	0, 100, 0	2.50	0.54	0.44	0, 100, 0	2.50	0.56	0.29	0, 100, 0	2.95	0.45	-0.16	0, 100, 0	2.70	0.65	0.38
8/30/2001	0, 100, 0	2.00	0.42	0.21	0, 100, 0	2.25	0.44	0.20	0, 100, 0	1.60	0.22	0.14	0, 100, 0	2.10	0.44	0.21
9/5/2001	0, 100, 0	4.00	0.51	0.31	0, 100, 0	4.10	0.51	0.32	0, 100, 0	4.30	0.39	0.19	0, 100, 0	4.05	0.51	0.33
9/11/2001	0, 75, 25	2.15	0.6	0.55	0, 75, 25	1.90	0.67	0.48	0, 100, 0	1.15	0.51	0.45	0, 50, 50	2.05	0.54	0.25

Appendix C-5. Physical habitat data surrounding fish 161 from August 9, 2000 to September 15, 2001.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
8/9/2000	0, 100, 0	1.30	0.64	0.43	0, 100, 0	1.30	0.59	0.16	0, 100, 0	1.50	0.52	0.01	0, 100, 0	1.30	0.65	0.45
8/18/2000	0, 100, 0	3.60	0.70	0.20	0, 100, 0	3.80	0.74	0.33	0, 100, 0	3.80	0.63	0.33	0, 100, 0	3.80	0.70	0.04
8/29/2000	0, 90, 10	2.60	0.61	0.43	0, 90, 10	2.70	0.54	0.19	0, 90, 10	2.70	0.58	0.14	0, 90, 10	2.90	0.59	0.29
8/31/2000	0, 100, 0	1.70	0.39	0.19	0, 100, 0	2.20	0.62	0.46	0, 100, 0	2.20	0.52	0.40	0, 100, 0	2.00	0.39	0.25
9/12/2000	0, 95, 5	2.20	0.61	0.43	0, 60, 40	1.80	0.78	0.61	0, 90, 10	2.00	0.64	0.48	0, 100, 0	2.80	0.60	-0.01
9/21/2000	0, 100, 0	1.80	0.56	0.17	0, 100, 0	2.00	0.62	0.47	0, 100, 0	1.90	0.46	0.32	0, 100, 0	1.80	0.52	0.49
10/3/2000	0, 100, 0	2.00	0.77	0.65	0, 100, 0	1.20	0.55	0.50	0, 100, 0	1.65	0.73	0.24	0, 100, 0	2.80	0.61	-0.06
10/26/2000	0, 100, 0	3.00	0.53	-0.05	0, 100, 0	1.80	0.75	0.52	0, 100, 0	1.90	0.5	0.37	0, 100, 0	1.80	0.51	0.44
5/31/2001	0, 100, 0	2.00	0.60	0.54	0, 95, 5	1.70	0.57	0.57	0, 100, 0	1.90	0.64	0.51	0, 100, 0	1.95	0.62	0.44
6/6/2001	0, 50, 50	3.80	0.79	0.34	0, 100, 0	4.20	0.92	-0.05	0, 90, 10	3.20	0.85	0.74	0, 100, 0	4.35	0.78	0.33
6/13/2001	0, 90, 10	7.70	0.93	0.83	0, 90, 10	8.10	0.91	0.52	0, 75, 25	6.70	0.81	0.43	0, 90, 10	7.80	1.02	0.45
6/21/2001	0, 95, 5	5.50	0.93	0.35	0, 100, 0	3.80	0.92	0.64	0, 75, 25	3.80	0.75	0.47	0, 80, 20	4.00	0.76	0.28
6/27/2001	0, 100, 0	2.60	0.67	0.51	0, 100, 0	2.60	0.43	0.37	0, 100, 0	2.80	0.34	0.21	0, 100, 0	3.05	0.58	0.34
7/5/2001	0, 100, 0	3.20	0.91	0.23	0, 100, 0	3.80	0.93	0.76	0, 100, 0	3.50	0.83	0.62	0, 100, 0	3.45	0.78	0.42
7/11/2001	0, 50, 50	1.90	0.46	0.38	0, 25, 75	1.90	0.48	0.45	0, 25, 75	1.50	0.41	0.33	0, 50, 50	2.00	0.51	0.41
7/17/2001	0, 100, 0	2.10	0.54	0.26	0, 100, 0	2.20	0.67	-0.02	0, 100, 0	2.25	0.63	0.24	0, 100, 0	2.05	0.58	0.29
7/25/2001	0, 100, 0	1.90	0.44	0.31	0, 100, 0	3.20	0.62	0.44	0, 100, 0	3.80	0.52	0.34	0, 100, 0	3.00	0.56	0.35
8/2/2001	0, 90, 10	1.90	0.61	0.71	0, 90, 10	2.60	0.64	0.32	0, 100, 0	2.25	0.66	-0.08	0, 100, 0	2.80	0.62	-0.03
8/7/2001	0, 100, 0	2.75	0.55	0.31	0, 100, 0	2.30	0.42	0.29	0, 90, 10	2.35	0.63	0.51	0, 100, 0	2.40	0.46	0.15
8/14/2001	0, 75, 25	5.00	0.32	0.18	0, 100, 0	4.30	0.96	0.38	0, 100, 0	4.55	0.82	0.04	0, 100, 0	4.40	0.77	0.52
8/23/2001	0, 100, 0	2.30	1.07	0.80	0, 100, 0	2.50	0.90	0.71	0, 100, 0	3.60	0.72	0.09	0, 100, 0	2.50	0.68	0.55
8/30/2001	0, 100, 0	1.15	0.63	0.49	0, 100, 0	2.55	0.54	-0.13	0, 100, 0	2.60	0.59	0.38	0, 100, 0	2.15	0.58	-0.02
9/5/2001	0, 100, 0	2.55	0.45	0.42	0, 100, 0	3.05	0.45	0.34	0, 100, 0	3.05	0.41	0.18	0, 100, 0	2.70	0.46	0.32
9/11/2001	0, 100, 0	3.40	0.47	0.28	0, 100, 0	3.40	0.82	0.71	0, 100, 0	4.15	0.72	0.47	0, 100, 0	3.75	0.89	0.69
9/26/2001	0, 100, 0	3.10	1.01	0.57	0, 100, 0	3.35	1.00	0.61	0, 100, 0	3.50	1.01	0.51	0, 100, 0	3.75	1.02	0.63
10/3/2001	0, 100, 0	2.55	0.59	0.49	0, 100, 0	3.30	0.63	0.52	0, 100, 0	1.60	0.82	0.79	0, 100, 0	2.80	0.59	0.36
10/8/2001	0, 100, 0	2.80	0.78	0.61	0, 100, 0	3.50	0.68	0.22	0, 100, 0	3.10	0.61	0.41	0, 100, 0	3.30	0.65	0.39
10/15/2001	0, 100, 0	2.70	0.82	0.53	0, 100, 0	3.30	0.72	0.43	0, 100, 0	3.75	0.68	0.41	0, 100, 0	3.40	0.64	0.38

Appendix C-6. Physical habitat data surrounding fish 181 from July 20, 2000 to August 31, 2000.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
7/20/2000	0, 100, 0	0.90	-	-	0, 100, 0	1.00	-	-	0, 100, 0	0.90	-	-	0, 100, 0	1.10	-	-
7/26/2000	0, 100, 0	2.80	0.47	0.42	0, 100, 0	1.80	0.86	0.7	0, 100, 0	2.20	0.68	0.15	0, 100, 0	0.90	0.67	0.61
7/28/2000	0, 100, 0	2.20	0.59	0.41	0, 100, 0	2.00	0.49	0.31	0, 100, 0	1.80	0.49	0.36	0, 100, 0	2.20	0.62	0.41
8/1/2000	0, 100, 0	3.00	1.00	0.84	0, 100, 0	3.60	0.82	0.4	0, 100, 0	3.00	0.80	0.44	0, 100, 0	3.50	0.65	0.52
8/31/2000	0, 95, 5	1.80	0.61	0.48	0, 95, 5	1.90	0.61	0.42	0, 95, 5	2.20	0.58	0.2	0, 95, 5	1.80	0.73	0.62

Appendix C-7. Physical habitat data surrounding fish 201/401 from August 11, 2000 to October 17, 2002.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
8/11/2000	0, 100, 0	2.60	0.57	0.38	0, 100, 0	4.10	0.73	-0.03	0, 100, 0	5.90	0.78	0.28	0, 100, 0	3.40	0.76	0.40
8/15/2000	0, 95, 5	2.80	0.53	0.07	0, 100, 0	3.70	0.49	0.02	0, 95, 5	3.90	0.46	0.36	0, 95, 5	3.90	0.52	0.31
8/18/2000	0, 100, 0	3.00	0.67	0.01	0, 100, 0	3.10	0.62	0.28	0, 100, 0	2.90	0.63	0.29	0, 100, 0	2.80	0.60	0.17
8/31/2000	0, 90, 10	2.80	0.52	0.24	0, 90, 10	2.80	0.61	0.55	0, 90, 10	3.00	0.53	0.12	0, 90, 10	2.50	0.45	0.48
9/3/2000	0, 100, 0	3.60	0.42	0.21	0, 100, 0	3.90	0.45	0.19	50, 50, 0	2.40	0.13	0.06	0, 100, 0	3.10	0.69	0.10
9/12/2000	0, 100, 0	5.40	0.68	0.28	0, 100, 0	5.60	0.72	0.37	0, 100, 0	5.80	0.77	0.39	0, 100, 0	5.60	0.67	0.34
9/21/2000	0, 100, 0	2.80	0.26	0.25	0, 100, 0	4.80	0.36	0.24	0, 100, 0	3.20	0.71	0.41	0, 100, 0	4.00	0.37	0.28
10/12/2000	0, 100, 0	1.40	0.50	0.50	0, 100, 0	1.30	4.30	0.36	0, 100, 0	1.40	0.49	0.40	0, 100, 0	1.60	0.40	0.36
10/26/2000	0, 100, 0	2.90	0.35	0.19	0, 100, 0	2.25	0.42	0.34	0, 100, 0	2.20	0.42	0.40	0, 100, 0	2.10	0.53	0.43
5/24/2001	0, 100, 0	2.25	0.49	0.34	0, 100, 0	2.00	0.84	0.76	0, 100, 0	3.30	0.64	-0.01	0, 100, 0	1.90	0.78	0.62
6/1/2001	25, 75, 0	4.10	0.42	0.21	25, 75, 0	4.10	0.43	0.21	25, 75, 0	3.90	0.30	0.14	25, 75, 0	4.00	0.41	0.22
6/5/2001	25, 75, 0	3.30	0.52	0.34	0, 100, 0	3.70	0.58	0.44	25, 75, 0	3.30	0.44	0.24	50, 50, 0	3.60	0.53	0.34
6/12/2001	0, 100, 0	3.95	0.41	0.34	0, 100, 0	3.00	0.49	0.29	0, 100, 0	3.00	0.41	0.35	0, 100, 0	3.00	0.28	0.16
6/20/2001	0, 100, 0	3.80	1.11	0.82	0, 100, 0	4.10	0.98	0.49	0, 100, 0	3.45	1.20	0.78	0, 100, 0	3.75	1.06	0.89
6/26/2001	0, 100, 0	3.20	0.69	0.54	0, 95, 5	2.40	0.51	0.44	0, 100, 0	1.80	0.33	0.26	0, 90, 10	2.70	0.53	0.43
7/3/2001	0, 100, 0	2.20	0.91	0.83	0, 100, 0	3.00	0.77	0.59	0, 100, 0	3.80	0.82	-0.15	0, 100, 0	2.70	0.85	0.46
7/10/2001	0, 90, 10	2.05	0.44	0.37	0, 75, 25	2.00	0.45	0.36	0, 90, 10	2.00	0.43	0.34	0, 75, 25	2.00	0.44	0.35
7/17/2001	0, 100, 0	1.65	0.47	0.36	0, 100, 0	1.45	0.52	0.41	0, 100, 0	1.40	0.47	0.33	0, 100, 0	1.40	0.45	0.36
7/25/2001	0, 100, 0	2.45	0.86	0.67	0, 90, 10	2.55	0.94	0.68	0, 50, 50	2.60	0.78	0.61	0, 75, 25	2.60	0.83	0.56
8/2/2001	0, 100, 0	1.80	0.46	0.37	0, 100, 0	1.75	0.45	0.36	0, 100, 0	1.80	0.42	0.35	0, 100, 0	2.00	0.41	0.24
8/7/2001	0, 90, 10	2.05	0.66	0.48	0, 50, 50	2.40	0.59	0.64	0, 100, 0	3.20	0.53	0.46	0, 75, 25	2.30	0.76	0.45
8/16/2001	0, 100, 0	3.85	0.61	0.32	0, 100, 0	4.00	0.76	0.40	0, 100, 0	4.20	0.75	0.40	0, 100, 0	3.50	0.61	0.46
8/23/2001	0, 100, 0	2.90	0.61	0.27	0, 100, 0	3.00	0.74	0.49	0, 100, 0	2.40	0.56	0.36	0, 100, 0	3.00	0.71	0.36
8/30/2001	0, 50, 50	1.60	0.49	0.33	0, 25, 75	1.75	0.61	0.41	0, 75, 25	1.85	0.57	0.32	0, 50, 50	1.80	0.54	0.25
9/5/2001	0, 100, 0	1.95	0.36	0.24	0, 100, 0	1.40	0.27	0.22	0, 100, 0	1.40	0.33	0.18	0, 100, 0	1.80	0.36	0.29
9/12/2001	0, 100, 0	1.85	0.37	0.32	0, 100, 0	2.10	0.56	0.43	0, 100, 0	1.85	0.53	0.43	0, 90, 10	2.05	0.49	0.36
9/20/2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix C-7. Continued (*12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
9/26/2001	0, 100, 0	3.10	1.01	0.57	0, 100, 0	3.35	1.00	0.61	0, 100, 0	3.50	1.01	0.51	0, 100, 0	3.75	1.02	0.63
10/15/2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11/1/2001	0, 100, 0	4.65	0.66	0.41	0, 100, 0	4.60	0.71	0.35	0, 100, 0	4.90	0.78	0.38	0, 100, 0	5.00	0.63	0.26
11/7/2001	0, 100, 0	3.40	0.80	0.28	0, 100, 0	4.95	0.89	-0.03	0, 100, 0	3.80	0.94	0.54	0, 100, 0	4.70	0.84	0.67
12/5/2001	0, 100, 0	2.40	0.78	0.57	0, 100, 0	1.95	0.58	0.32	0, 100, 0	2.30	0.78	0.63	0, 100, 0	2.15	0.57	0.27
3/12/2002	0, 100, 0	3	0.46	0.2	0, 100, 0	4.9	0.85	0.00	0, 100, 0	4.3	0.8	0.56	0, 100, 0	4.70	0.78	0.51
4/4/2002	0, 100, 0	1.9	0.37	0.31	0, 100, 0	3.9	0.68	0.09	0, 100, 0	6.3	0.71	0.38	0, 100, 0	3.90	0.54	0.46
4/18/2002	0, 100, 0	2.35	0.41	0.32	0, 100, 0	2.3	0.42	0.29	0, 100, 0	1.8	0.48	0.39	0, 100, 0	2.40	0.43	0.31
5/2/2002	0, 100, 0	6.35	1.02	0.14	0, 100, 0	5.7	1.02	0.28	0, 100, 0	5.00	0.98	0.68	0, 100, 0	6.00	0.76	0.33
5/8/2002	0, 100, 0	4.9	0.78	0.41	0, 100, 0	4.8	0.68	0.12	0, 100, 0	4.50	0.75	0.44	0, 100, 0	4.80	0.84	0.48
5/14/2002	0, 100, 0	2.25	0.67	0.58	0, 100, 0	2.30	0.87	0.78	0, 100, 0	1.80	0.92	0.77	0, 100, 0	2.85	0.71	0.10
5/21/2002*	0, 100, 0	2.1	0.84	0.76	0, 100, 0	2.50	0.94	0.06	0, 100, 0	2.45	0.64	0.51	0, 100, 0	2.75	0.71	0.56
5/28/2002	0, 100, 0	2.95	0.62	-0.03	0, 100, 0	3.05	0.68	0.34	0, 100, 0	2.90	0.45	0.24	0, 100, 0	2.60	0.56	0.23
6/6/2002*	0, 100, 0	3.20	0.28	0.19	0, 100, 0	5.05	0.39	0.22	0, 100, 0	5.35	0.33	0.18	0, 100, 0	4.60	0.37	0.26
6/13/2002	0, 100, 0	1.65	0.61	0.46	0, 100, 0	1.10	0.69	0.58	0, 100, 0	1.70	0.47	0.31	0, 100, 0	1.20	0.68	0.48
6/14/2002	0, 100, 0	3.4	0.85	0.41	0, 100, 0	3.75	0.89	0.55	0, 100, 0	3.50	0.89	0.64	0, 100, 0	3.80	0.95	0.46
6/18/2002	0, 100, 0	3.5	0.69	0.54	0, 100, 0	4.80	0.57	0.12	0, 100, 0	4.95	0.61	0.17	0, 100, 0	3.25	0.68	0.39
7/2/2002	0, 100, 0	2.2	0.46	0.34	0, 90, 10	2.55	0.45	0.07	0, 100, 0	1.75	0.50	0.32	0, 90, 10	2.00	0.42	0.32
7/10/2002	0, 100, 0	2.4	0.52	-0.08	0, 100, 0	2.70	0.49	0.41	0, 100, 0	2.30	0.72	0.44	0, 100, 0	2.40	0.61	0.44
7/16/2002	0, 100, 0	3.8	0.73	0.16	0, 100, 0	4.00	0.74	0.43	0, 100, 0	4.70	0.64	0.05	0, 100, 0	4.10	0.68	0.43
8/1/2002*	0, 100, 0	1.65	0.38	0.11	0, 100, 0	1.40	0.44	0.34	0, 100, 0	1.90	0.39	-0.19	0, 100, 0	1.45	0.35	0.33
8/7/2002	0, 100, 0	2	0.54	0.45	0, 100, 0	2.10	0.49	0.40	0, 100, 0	2.00	0.45	0.31	0, 100, 0	2.40	0.48	0.38
8/13/2002	0, 100, 0	1.75	0.3	0.27	0, 100, 0	1.75	0.30	0.22	0, 100, 0	1.70	0.33	0.21	0, 100, 0	1.70	0.18	0.13
8/22/2002	0, 100, 0	1.85	0.39	0.34	0, 100, 0	2.10	0.30	0.19	0, 100, 0	2.30	0.37	0.24	0, 100, 0	1.80	0.25	0.20
8/26/2002	0, 100, 0	3.20	0.33	0.19	0, 100, 0	3.30	0.22	0.15	0, 100, 0	2.40	0.39	0.20	0, 100, 0	3.40	0.28	0.22
8/29/2002	0, 100, 0	3.15	0.56	0.43	0, 100, 0	3.30	0.67	0.47	0, 100, 0	3.30	0.57	0.37	0, 100, 0	3.30	0.69	0.37
9/3/2002*	0, 100, 0	3.70	0.75	0.39	0, 100, 0	3.00	0.82	0.52	0, 100, 0	3.05	0.68	0.47	0, 100, 0	3.15	0.76	0.63
9/28/2002	0, 100, 0	2.00	0.38	0.30	0, 100, 0	1.50	0.25	0.21	0, 100, 0	1.20	0.17	0.08	0, 100, 0	2.10	0.33	0.27
10/17/2002	0, 100, 0	3	0	-0.15	0, 100, 0	3.80	0.51	0.14	0, 100, 0	3.40	0.50	0.25	0, 100, 0	3.00	0.56	0.30

Appendix C-8. Physical habitat data surrounding fish 241 from April 9, 2002 to October 12, 2002 (*12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
4/9/2002	0, 100, 0	7.6	0.64	0.61	0, 100, 0	7.6	0.59	0.3	0, 100, 0	7.2	0.58	0.33	0, 100, 0	7.6	0.56	0.52
4/17/2002	0, 100, 0	3.3	0.66	0.6	0, 100, 0	2.5	0.91	0.87	0, 100, 0	2.95	0.8	0.3	0, 100, 0	2.9	1.06	0.33
5/1/2002	0, 100, 0	3.5	0.76	0.36	0, 100, 0	3.55	0.94	0.23	0, 100, 0	3.1	0.81	0.46	0, 100, 0	3.45	0.77	0.38
5/14/2002	0, 100, 0	5.8	0.99	0.43	0, 100, 0	5.2	1.02	0.05	0, 100, 0	6.3	0.98	0.41	0, 100, 0	5.4	1.08	0.32
5/16/2002	0, 100, 0	3.10	0.64	0.21	0, 100, 0	2.45	1.09	0.15	0, 100, 0	2.10	0.93	0.88	0, 100, 0	2.50	1.09	0.78
5/23/2002	0, 100, 0	2.8	0.78	0.36	0, 100, 0	3.1	0.85	-0.06	0, 100, 0	2.85	0.78	0.52	0, 100, 0	2.5	0.92	0.66
6/6/2002	0, 100, 0	0.90	0.46	0.38	0, 100, 0	1.25	0.45	0.37	0, 100, 0	0.50	0.31	0.29	0, 100, 0	1.20	0.44	0.34
6/13/2002	0, 100, 0	2.65	0.73	0.47	0, 100, 0	3.9	0.57	-0.02	0, 100, 0	2.35	0.62	0.31	0, 100, 0	3.4	0.52	-0.13
6/17/2002	0, 100, 0	0.8	0.51	0.41	0, 100, 0	0.65	0.49	0.46	0, 100, 0	0.75	0.32	0.18	0, 100, 0	0.85	0.44	0.35
6/24/2002	0, 100, 0	1.25	0.38	0.32	0, 100, 0	1.5	0.38	0.08	0, 100, 0	1.4	0.43	0.37	0, 100, 0	1.2	0.58	0.43
6/26/2002	0, 100, 0	3	0.64	0.56	0, 100, 0	3.3	0.98	0.1	0, 100, 0	3.65	0.85	0.41	0, 100, 0	3.9	0.81	0.40
7/2/2002	0, 100, 0	2.3	0.35	0.28	0, 100, 0	2.45	0.27	0.21	0, 100, 0	2.4	0.26	0.16	0, 100, 0	2.45	0.39	0.27
7/10/2002	0, 100, 0	2.4	0.51	0.37	0, 100, 0	2.15	0.58	0.47	0, 100, 0	2.25	0.53	0.39	0, 100, 0	2.5	0.59	0.28
7/15/2002	0, 100, 0	2.25	0.51	0.36	0, 75, 25	2.3	0.54	0.37	0, 100, 0	2.5	0.52	0.23	0, 90, 10	2.3	0.49	0.44
7/23/2002	0, 100, 0	2.65	0.39	0.08	0, 90, 10	2.25	0.74	0.57	0, 100, 0	2.6	0.55	0.42	0, 100, 0	2.7	0.69	0.57
8/1/2002	0, 100, 0	1.05	0.26	0.19	0, 100, 0	1.05	0.25	0.14	0, 75, 25	1.1	0.42	0.35	0, 100, 0	1.15	0.38	0.3
8/7/2002	0, 90, 10	1.35	0.42	0.16	0, 50, 50	1.4	0.56	0.33	0, 25, 75	1.1	0.47	0.32	0, 50, 50	1.2	0.56	0.52
8/13/2002	0, 90, 10	1.9	0.49	0.31	0, 90, 10	2	0.57	0.31	0, 75, 25	1.6	0.61	0.4	0, 90, 10	1.6	0.59	0.37
8/22/2002	0, 100, 0	4.6	1.1	0.78	0, 100, 0	4.8	1.04	0.64	0, 100, 0	4.6	0.97	0.61	0, 100, 0	4.6	0.98	0.6
8/29/2002	0, 100, 0	2.6	0.43	0.22	0, 100, 0	2.5	0.42	0.35	0, 100, 0	1.7	0.41	0.3	0, 90, 10	2.3	0.47	0.28
9/17/2002	0, 100, 0	4.6	0.76	0.18	0, 100, 0	4.3	0.97	0.76	0, 100, 0	4.15	0.85	0.45	0, 100, 0	4.1	0.85	0.44
9/28/2002	0, 100, 0	1.90	0.32	0.19	0, 100, 0	2.00	0.35	0.26	0, 100, 0	1.80	0.40	0.27	0, 100, 0	1.80	0.49	0.38
10/9/2002	0, 100, 0	2.25	0.50	0.49	0, 100, 0	2.30	0.48	-0.03	0, 100, 0	2.30	0.51	-0.01	0, 100, 0	2.30	0.52	0.30
10/12/2002	0, 100, 0	3.3	0.7	0.17	0, 100, 0	3	0.62	0.59	0, 100, 0	2.8	0.62	-0.15	0, 100, 0	3.3	0.67	0.00

Appendix C-9. Physical habitat data surrounding fish 281 from April 17, 2002 to October 16, 2002 (*12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
4/17/2002	0, 100, 0	2.45	0.75	0.46	0, 100, 0	3.1	0.98	0.71	0, 100, 0	2.8	0.8	0.34	0, 90, 10	3.05	0.99	-0.01
5/2/2002	0, 100, 0	2.65	0.72	0.61	0, 100, 0	2.75	0.62	0.36	0, 100, 0	2.6	0.68	0.08	0, 100, 0	2.9	0.69	0.52
5/7/2002	0, 100, 0	1	0.55	0.54	0, 100, 0	1.1	0.66	0.64	0, 100, 0	1.3	0.48	0.37	0, 100, 0	1.4	0.51	0.15
5/14/2002	0, 100, 0	2.5	0.19	-0.06	0, 100, 0	5.2	1.16	0.32	0, 100, 0	6.1	0.87	0.48	0, 100, 0	5.85	1.12	0.55
5/16/2002*	0, 90, 10	1.35	0.48	0.27	0, 75, 25	1.45	0.38	0.28	0, 90, 10	1.20	0.51	0.31	0, 90, 10	1.30	0.65	0.57
5/23/2002	0, 100, 0	1.15	0.63	0.55	0, 100, 0	1.3	0.73	0.48	0, 100, 0	1.05	0.57	0.47	0, 100, 0	1.65	0.47	-0.04
6/5/2002	0, 100, 0	3.65	0.67	0.31	0, 100, 0	4.05	0.59	0.02	0, 100, 0	2.35	0.46	-0.05	0, 100, 0	3.3	0.55	0.36
6/11/2002	0, 100, 0	1.9	0.65	0.65	0, 100, 0	2.1	0.65	0.36	0, 100, 0	2	0.72	0.61	0, 100, 0	2.5	0.77	0.67
6/21/2002*	0, 100, 0	3	0.54	0.31	0, 100, 0	3.15	0.48	0.09	0, 100, 0	1.7	0.47	0.31	0, 100, 0	1.85	0.49	0.31
6/27/2002	0, 90, 10	1.8	0.51	0.29	0, 100, 0	1.8	0.48	0.28	0, 90, 10	1.8	0.54	0.01	0, 90, 10	2.6	0.47	-0.16
7/1/2002	0, 100, 0	1.95	0.3	0.17	0, 100, 0	1.9	0.3	0.09	0, 100, 0	1.7	0.26	0.16	0, 50, 50	2.3	0.31	0.23
7/11/2002*	0, 25, 75	0.90	0.51	0.45	0, 50, 50	0.80	0.77	0.55	0, 25, 75	0.90	0.58	0.50	0, 25, 75	1.00	0.68	0.52
7/17/2002	0, 100, 0	1.6	0.22	0.1	0, 75, 25	1.4	0.35	0.27	0, 75, 25	1.4	0.24	0.15	0, 100, 0	1.7	0.34	0.24
7/23/2002	25, 75, 0	1.7	0.63	0.45	0, 90, 10	1.55	0.64	0.50	0, 100, 0	1.6	0.63	0.45	0, 50, 50	1.8	0.68	0.47
7/30/2002	0, 75, 25	1.25	0.48	0.36	0, 25, 75	1.5	0.60	0.34	0, 100, 0	1.4	0.5	0.42	0, 50, 50	1.65	0.47	0.33
8/6/2002*	0, 100, 0	1.15	0.52	0.40	0, 100, 0	1.85	0.54	0.39	0, 100, 0	1	0.52	0.42	0, 100, 0	1.8	0.50	0.31
8/13/2002	0, 100, 0	1.35	0.14	0.08	0, 75, 25	1.6	0.34	0.23	0, 75, 25	2.15	0.42	0.34	0, 100, 0	1.45	0.16	0.15
8/20/2002	0, 90, 10	2.6	0.59	0.55	0, 100, 0	2.55	0.53	0.19	0, 100, 0	1.7	0.48	0.26	0, 100, 0	2.55	0.48	0.32
8/29/2002	0, 75, 25	3.05	0.54	0.42	0, 100, 0	2.65	0.48	0.39	0, 100, 0	1.6	0.43	0.36	0, 100, 0	2.65	0.45	0.3
9/5/2002	0, 100, 0	1.5	0.47	0.31	0, 100, 0	1.8	0.53	0.27	0, 100, 0	1.3	0.27	0.00	0, 100, 0	1.4	0.45	0.24
9/17/2002	0, 100, 0	1.7	0.49	0.21	0, 100, 0	2.3	0.57	0.38	0, 100, 0	1.4	0.73	0.71	0, 100, 0	1.7	0.57	0.4
10/9/2002	0, 100, 0	1	0.28	0.22	0, 100, 0	0.75	0.44	0.36	0, 100, 0	0.7	0.36	0.31	0, 100, 0	1.1	0.17	0.07
10/16/2002	0, 100, 0	1.35	0.45	0.33	0, 100, 0	1.3	0.57	0.4	0, 100, 0	1.3	0.57	0.4	0, 100, 0	1.6	0.42	0.07

Appendix C-10. Physical habitat data surrounding fish 301 from April 4, 2002 to October 17, 2002 (*12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
4/4/2002	0, 100, 0	3.15	0.64	0.00	0, 100, 0	1.85	0.73	0.62	0, 100, 0	2.5	0.71	0.11	0, 90, 10	2.9	0.56	0.23
4/18/2002	0, 100, 0	1.5	0.54	0.41	0, 100, 0	2	0.62	0.17	0, 100, 0	1.8	0.54	0.49	0, 100, 0	1.85	0.49	0.37
5/2/2002	0, 100, 0	2.55	0.94	0.57	0, 100, 0	3.3	0.84	0.61	0, 100, 0	4.1	0.75	0.37	0, 100, 0	3.5	0.71	0.41
5/8/2002	0, 100, 0	4.8	0.82	0.29	0, 100, 0	4.1	0.99	0.42	0, 100, 0	3.4	0.86	0.58	0, 100, 0	4.4	0.95	0.02
5/14/2002	0, 100, 0	2.4	0.65	0.47	0, 100, 0	2.45	0.76	0.44	0, 100, 0	2.25	0.76	0.76	0, 100, 0	2.9	0.57	0.38
5/28/2002	0, 100, 0	8.2	0.74	0.61	0, 100, 0	8.5	0.83	-	0, 100, 0	7.5	0.98	-	0, 100, 0	7.9	0.85	-
6/6/2002	0, 100, 0	3.6	0.63	0.49	0, 100, 0	2.9	0.77	0.66	0, 100, 0	2.85	0.82	0.71	0, 100, 0	3.6	0.62	0.53
6/13/2002	0, 100, 0	4.4	0.57	0.35	0, 100, 0	4.5	0.69	0.1	0, 100, 0	4.1	0.81	0.58	0, 100, 0	4.3	0.77	0.3
6/14/2002	0, 100, 0	4.9	0.92	0.4	0, 100, 0	4.1	1.07	0.8	0, 100, 0	4.7	1.19	0.79	0, 100, 0	4.6	0.97	0.35
6/17/2002	0, 100, 0	2.05	0.58	0.33	0, 100, 0	2.25	0.74	0.51	0, 100, 0	3.55	0.59	0.13	0, 100, 0	1.95	0.82	0.58
6/24/2002	0, 100, 0	3.15	0.78	0.44	0, 100, 0	3.05	0.74	0.57	0, 100, 0	2.95	0.66	0.4	0, 100, 0	3.35	0.65	0.52
6/26/2002*	0, 100, 0	4.7	0.70	0.00	0, 100, 0	4.7	0.69	0.64	0, 100, 0	5.2	0.62	0.16	0, 100, 0	4.55	0.76	0.33
7/2/2002	0, 100, 0	2.3	0.41	0.37	0, 100, 0	2.65	0.43	0.28	0, 100, 0	2.25	0.48	0.32	0, 100, 0	2.25	0.39	0.35
7/10/2002	0, 75, 25	1.7	0.62	0.42	0, 50, 50	1.55	0.61	0.52	0, 75, 25	1.15	0.53	0.45	0, 75, 25	1.45	0.58	0.55
7/15/2002	0, 75, 25	1.85	0.62	0.52	0, 75, 25	2.2	0.53	0.44	0, 90, 10	2.1	0.59	0.39	0, 90, 10	2.1	0.47	0.37
7/23/2002	0, 100, 0	1.8	0.41	0.31	0, 100, 0	1.95	0.41	0.19	0, 100, 0	1.75	0.43	0.35	0, 100, 0	1.85	0.4	0.33
8/1/2002	0, 100, 0	2.6	0.38	0.28	0, 100, 0	2.5	0.39	0.27	0, 100, 0	2.4	0.41	0.33	0, 100, 0	2.65	0.4	0.26
8/7/2002	0, 100, 0	0.65	0.29	0.26	0, 75, 25	1.8	0.49	0.46	0, 75, 25	1.85	0.57	0.43	0, 50, 50	2	0.49	0.25
8/13/2002	0, 100, 0	1.4	0.42	0.28	0, 90, 10	1.35	0.37	0.3	0, 100, 0	1.55	0.51	0.32	0, 100, 0	1.4	0.42	0.37
8/22/2002	0, 50, 50	1.75	0.25	0.17	10, 90, 0	1.7	0.25	0.16	10, 90, 10	1.75	0.27	0.18	10, 90, 10	1.65	0.24	0.12
8/26/2002	0, 100, 0	3.7	0.35	0.31	0, 75, 25	3.75	0.41	0.24	0, 90, 10	3.8	0.47	0.41	0, 100, 0	4.2	0.39	0.16
8/29/2002	0, 100, 0	1.8	0.48	0.13	0, 100, 0	1.6	0.6	0.52	0, 100, 0	1.7	0.61	0.51	0, 90, 10	2.2	0.54	0.34
9/3/2002*	0, 100, 0	2.45	0.57	-0.04	0, 100, 0	2.6	0.51	0.37	0, 100, 0	3.2	0.69	0.56	0, 100, 0	3.05	0.63	0.18
9/14/2002	0, 100, 0	1.5	0.43	0.28	0, 100, 0	1.3	0.4	0.34	0, 100, 0	1.6	0.38	0.26	0, 100, 0	1.5	0.48	0.35
10/3/2002	0, 100, 0	2.3	0.47	0.38	0, 100, 0	2.9	0.44	0.24	0, 100, 0	1.7	0.68	0.55	0, 100, 0	2	0.61	0.23
10/10/2002	0, 100, 0	3	0.49	0.47	0, 100, 0	3.3	0.73	0.34	0, 100, 0	3.25	0.67	0.57	0, 100, 0	2.5	0.62	0.54
10/17/2002	0, 100, 0	1.9	0.5	0.46	0, 100, 0	1.9	0.53	0.48	0, 100, 0	2.8	0.44	0.32	0, 100, 0	3.3	0.26	-0.13

Appendix C-11. Physical habitat data surrounding fish 381 from October 18, 2001 to October 17, 2002 (*12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
10/18/2001	0, 100, 0	5.1	0.71	0.52	0, 100, 0	5.5	0.91	0.33	0, 100, 0	5	0.83	0.45	0, 100, 0	4.75	0.88	0.61
10/31/2001	0, 100, 0	4.8	0.77	0.05	0, 100, 0	4.2	0.84	0.52	0, 100, 0	4.9	0.81	0.74	0, 100, 0	4.7	0.85	0.52
11/14/2001	0, 100, 0	2	0.36	-0.02	0, 100, 0	1.05	0.44	0.43	0, 100, 0	0.9	0.39	0.35	0, 100, 0	1.75	0.49	0.11
12/5/2001	0, 100, 0	3.3	0.92	0.44	0, 100, 0	3.7	0.7	0.11	0, 100, 0	3.75	0.96	0.38	0, 100, 0	3.4	0.57	0.11
3/13/2002	0, 100, 0	1.8	0.63	0.54	0, 100, 0	3	0.45	0.03	0, 100, 0	2.5	0.67	0.31	0, 100, 0	2.65	0.67	0.55
3/28/2002	0, 100, 0	3.3	0.6	0.47	0, 100, 0	3.6	0.91	0.00	0, 100, 0	2.05	0.67	0.59	0, 100, 0	3.2	0.51	0.16
4/9/2002	0, 100, 0	4.4	0.75	0.52	0, 100, 0	4.9	0.96	-0.03	0, 100, 0	4.1	0.87	0.66	0, 100, 0	4.3	0.73	0.48
4/17/2002	0, 100, 0	2.9	0.75	0.66	0, 100, 0	3.05	0.86	0.24	0, 100, 0	3.9	0.83	0.61	0, 100, 0	3.1	0.75	0.45
5/1/2002	0, 100, 0	2.25	0.28	0.16	0, 100, 0	2.85	0.35	0.14	0, 100, 0	2.8	0.44	0.32	0, 100, 0	2.4	0.3	0.17
5/7/2002	0, 100, 0	5.7	1.16	0.42	0, 100, 0	5.75	1.14	0.73	0, 100, 0	6.2	1.17	0.78	0, 100, 0	5.9	1.02	0.62
5/20/2002	0, 100, 0	3.65	0.79	0.27	0, 100, 0	3	0.88	0.33	0, 100, 0	4.35	0.77	0.18	0, 100, 0	2.7	0.99	0.86
5/28/2002	0, 100, 0	2.15	0.69	0.51	0, 75, 25	2.25	0.62	0.03	0, 75, 25	2.45	0.82	0.63	0, 75, 25	2.6	0.79	0.48
6/6/2002	0, 100, 0	2.3	0.48	0.33	0, 100, 0	2.75	0.42	0.22	0, 100, 0	2.6	0.53	0.38	0, 100, 0	2.65	0.51	0.36
6/13/2002	0, 100, 0	3	0.75	0.23	0, 100, 0	2.6	0.81	0.65	0, 100, 0	3	0.71	0.31	0, 100, 0	2.6	0.77	0.32
6/19/2002	0, 100, 0	5.1	0.86	0.73	0, 100, 0	6	0.95	0.44	0, 100, 0	5.85	0.96	0.65	0, 100, 0	5.55	0.95	0.52
6/24/2002	0, 100, 0	2.4	0.58	0.27	0, 100, 0	2.1	0.62	0.28	0, 100, 0	2.05	0.55	-0.03	0, 100, 0	2.15	0.53	0.15
7/2/2002	0, 100, 0	2.05	0.52	0.48	0, 100, 0	1.95	0.39	0.27	0, 100, 0	1.7	0.41	0.36	0, 100, 0	2.1	0.41	0.25
7/10/2002	0, 75, 25	2.35	0.16	0.02	0, 100, 0	3.75	0.53	0.3	0, 100, 0	3.2	0.72	0.09	0, 100, 0	3.7	0.48	0.37
7/15/2002	0, 100, 0	3.75	0.74	0.43	0, 100, 0	3.9	0.68	0.37	0, 100, 0	4.05	0.64	0.11	0, 100, 0	3.55	0.77	0.56
8/1/2002*	0, 100, 0	3.15	0.78	0.38	0, 100, 0	3.20	0.76	0.36	0, 100, 0	3.60	0.62	0.32	0, 100, 0	3.15	0.73	0.56
8/7/2002	0, 100, 0	1.25	0.46	0.38	0, 100, 0	1.5	0.47	-0.08	0, 100, 0	0.95	0.56	0.55	0, 90, 10	1.5	0.4	-0.04
8/13/2002	0, 100, 0	1.4	0.4	0.31	0, 100, 0	1.4	0.47	0.38	0, 100, 0	2.1	0.37	0.21	0, 100, 0	1.3	0.35	0.2
8/22/2002	0, 100, 0	4	0.78	0.5	0, 100, 0	2.9	0.95	0.8	0, 100, 0	3.45	0.62	0.45	0, 100, 0	3.8	0.65	0.33
8/29/2002	0, 100, 0	1.8	0.54	0.37	0, 100, 0	2.25	0.33	0.00	0, 50, 50	1.8	0.52	0.00	0, 75, 25	2	0.58	0.15
9/3/2002	0, 100, 0	1.3	0.46	0.31	0, 100, 0	1.6	0.57	0.39	0, 100, 0	1.5	0.63	0.42	0, 100, 0	1.3	0.52	0.41
9/11/2002*	0, 100, 0	2.5	0.42	0.38	0, 100, 0	3	0.53	0.37	0, 100, 0	2.95	0.51	0.38	0, 100, 0	3.1	0.54	0.41
10/17/2002	0, 100, 0	2.4	0.32	0.27	0, 100, 0	2.2	0.34	0.28	0, 100, 0	2	0.4	0.33	0, 100, 0	2	0.29	0.26

Appendix C-12. Physical habitat data surrounding fish 501 from August 29, 2000 to November 6, 2001.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
8/29/2000	0, 90, 10	3.00	0.51	0.30	0, 90, 10	2.20	0.58	0.45	0, 90, 10	2.20	0.44	0.23	0, 90, 10	3.10	0.52	0.40
10/3/2000	0, 100, 0	5.00	0.76	0.31	0, 100, 0	4.10	0.79	-0.05	0, 100, 0	3.70	0.74	0.03	0, 100, 0	3.70	0.75	0.18
10/12/2000	0, 100, 0	2.30	0.62	0.36	0, 100, 0	2.70	0.76	0.15	0, 100, 0	2.10	0.76	0.59	0, 100, 0	2.60	0.65	0.42
10/19/2000	0, 100, 0	5.40	0.68	0.42	0, 100, 0	4.50	0.88	0.14	0, 100, 0	4.30	0.84	-0.06	0, 100, 0	4.55	0.73	0.46
10/26/2000	0, 100, 0	4.50	0.77	0.50	0, 100, 0	4.50	0.76	0.16	0, 100, 0	2.40	0.71	0.33	0, 100, 0	3.50	0.72	0.49
10/31/2000	0, 100, 0	3.00	0.62	0.27	0, 100, 0	3.10	0.83	0.64	0, 100, 0	1.90	0.34	0.23	0, 100, 0	3.00	0.66	0.46
5/17/2001	0, 50, 50	2.10	0.78	0.21	0, 80, 20	2.00	0.86	0.26	0, 50, 50	2.30	0.82	0.65	0, 50, 50	2.70	0.78	0.49
5/23/2001	0, 100, 0	3.90	0.76	0.54	0, 100, 0	4.30	0.56	0.38	0, 100, 0	4.30	0.68	0.45	0, 100, 0	4.00	0.74	0.39
5/29/2001	0, 100, 0	3.50	-0.04	0.00	0, 100, 0	5.10	0.38	0.28	0, 100, 0	5.40	0.18	0.18	0, 100, 0	2.90	0.02	0.10
6/7/2001	0, 100, 0	3.20	0.67	0.01	0, 100, 0	2.60	0.82	0.74	0, 100, 0	3.20	0.91	0.55	0, 100, 0	2.70	0.69	0.46
6/12/2001	0, 100, 0	2.40	0.49	0.41	0, 100, 0	2.70	0.51	0.28	0, 100, 0	2.30	0.61	0.47	0, 100, 0	2.80	0.44	0.32
6/20/2001	0, 100, 0	3.30	0.73	0.62	0, 100, 0	3.90	0.72	-0.02	0, 100, 0	2.35	0.96	0.87	0, 100, 0	3.05	0.76	0.51
6/26/2001	0, 100, 0	3.50	0.57	0.28	0, 100, 0	3.70	0.69	0.41	0, 100, 0	3.90	0.66	0.49	0, 100, 0	3.20	0.63	0.46
7/3/2001	0, 100, 0	5.40	0.40	0.18	0, 100, 0	4.70	0.94	0.56	0, 100, 0	4.60	0.75	0.48	0, 100, 0	4.90	0.76	0.29
7/10/2001	0, 100, 0	1.10	0.58	0.47	0, 100, 0	1.85	0.55	0.52	0, 100, 0	1.50	0.47	0.31	0, 100, 0	1.30	0.57	0.41
7/17/2001	0, 100, 0	1.30	0.54	0.49	0, 100, 0	1.80	0.47	0.44	0, 100, 0	2.10	0.48	0.18	0, 100, 0	1.50	0.58	0.54
7/26/2001	0, 75, 25	3.10	0.81	0.28	0, 100, 0	2.10	0.79	0.68	0, 100, 0	2.20	0.69	0.62	0, 100, 0	3.00	0.68	0.48
8/2/2001	0, 100, 0	1.45	0.54	0.46	0, 100, 0	1.60	0.56	0.47	0, 100, 0	1.90	0.58	0.12	0, 100, 0	1.40	0.58	0.53
8/7/2001	0, 75, 25	2.20	0.50	0.13	0, 100, 0	1.45	0.51	0.45	0, 100, 0	1.40	0.38	0.06	0, 75, 25	1.70	0.30	0.26
10/31/2001	0, 100, 0	2.40	0.53	0.29	0, 100, 0	2.00	0.62	0.49	0, 100, 0	2.30	0.52	0.46	0, 100, 0	2.30	0.68	0.36
11/6/2001	0, 100, 0	5.80	0.86	0.08	0, 100, 0	5.45	0.77	0.53	0, 100, 0	5.70	0.86	0.49	0, 100, 0	5.40	0.84	0.53

Appendix C-13. Physical habitat data surrounding fish 521 from May 24, 2001 to April 4, 2002.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
5/24/2001	0, 100, 0	4.35	1.08	0.79	0, 100, 0	4.90	1.20	0.92	0, 100, 0	5.50	1.08	0.64	0, 100, 0	5.70	0.89	0.62
6/1/2001	0, 100, 0	4.60	0.98	0.81	0, 100, 0	4.80	0.79	0.62	0, 100, 0	5.00	0.83	0.36	0, 100, 0	5.50	0.75	0.51
6/5/2001	0, 100, 0	10.10	0.62	-	0, 100, 0	10.50	0.58	-	0, 100, 0	9.50	0.64	-	0, 100, 0	10.10	0.65	-
6/12/2001	0, 100, 0	10.10	1.12	-	0, 100, 0	10.30	0.97	-	0, 100, 0	10.20	0.89	-	0, 100, 0	9.50	0.99	-
6/20/2001	0, 100, 0	2.30	0.57	0.42	0, 100, 0	1.80	0.73	0.69	0, 100, 0	1.80	0.53	0.44	0, 100, 0	1.80	0.59	0.54
6/21/2001	0, 100, 0	1.65	0.84	0.45	0, 100, 0	2.00	0.59	0.52	0, 100, 0	2.40	0.52	0.33	0, 100, 0	1.50	0.71	0.63
6/26/2001	0, 100, 0	8.00	0.83	0.40	0, 100, 0	7.70	0.72	0.59	0, 100, 0	5.80	0.86	0.62	0, 100, 0	6.70	0.63	0.54
7/3/2001	0, 100, 0	2.40	0.41	0.27	0, 100, 0	1.85	0.39	0.25	0, 100, 0	1.40	0.41	0.27	0, 100, 0	1.50	0.36	0.34
7/17/2001	0, 100, 0	1.35	0.43	0.34	0, 100, 0	1.55	0.47	0.32	0, 100, 0	1.10	0.49	0.49	0, 100, 0	1.50	0.69	0.51
7/26/2001	0, 100, 0	3.30	0.60	0.37	0, 100, 0	3.30	0.56	0.37	0, 100, 0	2.55	0.17	0.08	0, 100, 0	2.90	0.02	-0.03
7/31/2001	0, 75, 25	1.50	0.51	0.39	0, 75, 25	1.50	0.50	0.39	0, 75, 25	1.30	0.71	0.69	0, 50, 50	1.60	0.49	0.24
8/7/2001	0, 50, 50	2.90	0.63	0.36	0, 75, 25	2.95	0.64	0.46	0, 75, 25	2.60	0.56	0.43	0, 90, 10	3.00	0.66	0.46
8/16/2001	0, 100, 0	3.35	0.21	0.17	0, 100, 0	3.90	0.40	0.24	0, 100, 0	4.25	0.49	0.29	0, 100, 0	3.50	0.42	0.30
8/24/2001	0, 100, 0	2.10	0.41	0.28	0, 100, 0	2.20	0.32	0.16	0, 100, 0	2.15	0.29	0.18	0, 100, 0	2.10	0.31	0.22
8/30/2001	0, 100, 0	2.40	0.32	0.27	0, 100, 0	2.10	0.36	0.15	0, 100, 0	1.80	0.23	0.12	0, 100, 0	2.00	0.24	0.16
9/5/2001	0, 100, 0	2.00	0.56	0.48	0, 100, 0	2.55	0.48	0.41	0, 100, 0	2.45	0.57	0.46	0, 100, 0	2.55	0.53	0.32
9/11/2001	0, 100, 0	1.90	0.58	0.42	0, 75, 25	1.85	0.58	0.26	0, 100, 0	1.65	0.42	0.34	0, 100, 0	1.60	0.54	0.31
9/20/2001	0, 100, 0	1.85	0.58	0.45	0, 100, 0	2.00	0.43	0.21	0, 100, 0	1.90	0.42	0.32	0, 100, 0	1.85	0.40	0.28
10/4/2001	0, 100, 0	1.70	0.54	0.43	0, 100, 0	1.70	0.47	0.34	0, 100, 0	1.50	0.50	0.44	0, 100, 0	1.75	0.53	0.41
10/15/2001	0, 100, 0	3.70	0.45	0.28	0, 100, 0	3.50	0.47	0.32	0, 100, 0	3.25	0.32	0.22	0, 100, 0	3.40	0.41	0.23
11/1/2001	0, 100, 0	3.75	0.39	0.21	0, 100, 0	2.30	0.56	0.42	0, 100, 0	2.25	0.57	0.36	0, 100, 0	2.75	0.46	0.29
11/7/2001	0, 100, 0	3.70	0.66	0.38	0, 100, 0	3.10	0.69	0.13	0, 100, 0	3.45	0.79	0.27	0, 100, 0	3.20	0.62	0.35
12/5/2001	0, 100, 0	4.20	0.55	0.22	0, 100, 0	4.25	0.43	0.22	0, 100, 0	3.85	0.47	0.24	0, 100, 0	3.90	0.41	0.27
3/12/2002	0, 100, 0	2.4	0.26	0.16	0, 100, 0	3	0.42	0.25	0, 100, 0	1.7	0.6	0.4	0, 100, 0	1.7	0.44	0.3
4/4/2002	0, 100, 0	3	0.71	0.12	0, 100, 0	4.95	0.66	0.21	0, 100, 0	4.55	0.88	0.67	0, 100, 0	4.5	0.62	0.31

Appendix C-14. Physical habitat data surrounding fish 641 from August 22, 2000 to October 18, 2001.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
8/22/2000	0, 100, 0	4.00	0.36	0.17	0, 100, 0	4.00	0.36	0.22	0, 100, 0	4.00	0.27	0.17	0, 100, 0	4.00	0.29	0.15
9/28/2000	0, 100, 0	3.90	0.61	0.35	0, 100, 0	4.80	0.75	0.37	0, 100, 0	5.30	0.89	0.13	0, 100, 0	4.70	0.74	0.35
10/3/2000	0, 100, 0	4.10	0.76	0.5	0, 100, 0	3.60	0.79	0.19	0, 100, 0	3.00	0.82	0.09	0, 100, 0	3.80	0.89	0.34
10/12/2000	0, 100, 0	2.90	0.68	0.53	0, 100, 0	3.40	0.91	0.15	0, 100, 0	3.80	0.86	0.49	0, 100, 0	3.20	0.96	0.36
10/17/2000	0, 100, 0	8.40	0.61	0.33	0, 100, 0	8.10	0.62	0.19	0, 100, 0	8.40	0.58	0.36	0, 100, 0	7.90	0.62	0.45
10/31/2000	0, 100, 0	4.60	0.62	0.08	0, 100, 0	5.80	0.58	0.43	0, 100, 0	6.70	0.64	0.47	0, 100, 0	5.80	0.33	0.11
5/23/2001	0, 100, 0	2.80	0.57	0.36	0, 100, 0	3.30	0.65	0.49	0, 100, 0	4.00	0.64	0.11	0, 100, 0	3.20	0.63	0.37
6/1/2001	0, 90, 10	1.80	0.70	0.63	0, 95, 5	1.60	0.73	0.58	0, 100, 0	2.00	0.62	0.19	0, 100, 0	2.60	0.62	0.18
6/4/2001	0, 100, 0	1.55	0.62	0.56	0, 100, 0	1.60	0.81	0.68	0, 100, 0	1.90	0.74	0.53	0, 100, 0	1.80	0.59	0.51
6/6/2001	0, 100, 0	4.00	0.83	0.46	0, 100, 0	3.10	0.76	0.52	0, 100, 0	3.00	0.72	0.41	0, 100, 0	3.80	0.66	0.09
6/13/2001	0, 100, 0	3.60	0.77	0.29	0, 100, 0	4.80	0.96	0.42	0, 100, 0	4.10	0.87	0.61	0, 100, 0	4.40	0.92	0.62
6/21/2001	0, 100, 0	1.90	0.53	0.39	0, 100, 0	1.60	0.36	0.07	0, 100, 0	1.70	0.69	0.66	0, 100, 0	1.95	0.64	0.46
6/27/2001	0, 100, 0	3.30	0.78	0.58	0, 100, 0	2.90	0.64	0.59	0, 100, 0	1.50	0.66	0.34	0, 100, 0	3.30	0.55	0.12
7/5/2001	0, 100, 0	1.45	0.52	0.33	0, 100, 0	2.40	0.56	0.36	0, 100, 0	2.20	0.58	0.49	0, 100, 0	2.50	0.59	0.35
7/12/2001	0, 100, 0	1.20	0.47	0.36	0, 50, 50	1.40	0.48	0.37	0, 25, 75	1.40	0.48	0.43	0, 50, 50	1.45	0.52	0.39
7/17/2001	0, 100, 0	1.65	0.66	0.61	0, 100, 0	1.60	0.59	0.46	0, 100, 0	1.80	0.47	0.12	0, 100, 0	1.85	0.66	0.58
7/31/2001	0, 90, 10	2.90	0.61	-0.09	0, 100, 0	3.10	0.54	0.47	0, 75, 25	3.25	0.7	-0.06	0, 100, 0	2.90	0.58	0.28
8/7/2001	0, 100, 0	3.80	0.80	0.4	0, 100, 0	2.40	0.71	0.64	0, 100, 0	2.60	0.71	0.6	0, 100, 0	2.80	0.69	0.51
8/16/2001	0, 100, 0	4.00	0.56	0.42	0, 100, 0	4.00	0.63	0.38	0, 100, 0	3.50	0.69	0.48	0, 100, 0	4.00	0.63	0.40
8/24/2001	0, 100, 0	3.60	0.80	0.12	0, 100, 0	3.40	0.72	0.28	0, 100, 0	3.90	0.67	0.33	0, 100, 0	3.40	0.87	0.67
8/30/2001	0, 90, 10	3.20	0.74	0.47	0, 90, 10	3.25	0.62	0.37	0, 90, 10	3.30	0.75	0.56	0, 90, 10	3.45	0.59	0.31
9/20/2001	0, 100, 0	5.30	1.08	0.56	0, 100, 0	5.30	1.24	0.29	0, 100, 0	5.20	1.13	0.73	0, 100, 0	5.10	0.93	0.36
10/18/2001	0, 100, 0	3.80	0.75	0.41	0, 100, 0	4.15	0.84	0.62	0, 100, 0	4.70	0.6	0.41	0, 100, 0	3.80	0.72	0.13

Appendix C-15. Physical habitat data surrounding fish 661 from October 15, 2001 to May 20, 2002.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
10/15/2001	0, 100, 0	3.1	0.54	0.04	0, 100, 0	3.25	0.55	0.39	0, 100, 0	3.3	0.55	0.22	0, 100, 0	3.2	0.57	0.25
11/1/2001	0, 100, 0	1.85	0.32	0.21	0, 100, 0	1.8	0.26	0.19	0, 100, 0	2	0.24	0.16	0, 100, 0	1.8	0.36	0.23
11/5/2001	0, 100, 0	3.4	0.75	0.08	0, 100, 0	2.4	0.86	0.76	0, 100, 0	2.6	0.58	0.1	0, 100, 0	3.4	0.59	0.01
12/5/2001	0, 100, 0	3.5	0.77	0.45	0, 100, 0	3.9	0.64	0.29	0, 100, 0	4.6	0.82	-0.16	0, 100, 0	3.25	0.58	0.52
3/13/2002	0, 100, 0	4.1	0.49	0.22	0, 100, 0	4	0.6	0.32	0, 100, 0	3.9	0.61	0.32	0, 100, 0	3.65	0.45	0.31
3/28/2002	0, 100, 0	2.4	0.24	0.12	0, 100, 0	1.95	0.3	0.19	0, 100, 0	2	0.38	0.21	0, 100, 0	2.1	0.01	-0.01
4/17/2002	0, 100, 0	2.3	0.54	0.38	0, 100, 0	2.2	0.45	0.35	0, 100, 0	2	0.31	0.18	0, 100, 0	2.3	0.36	0.24
5/1/2002	0, 100, 0	3.1	0.26	0.04	0, 100, 0	3.25	0.23	0.22	0, 100, 0	1.8	0.08	-0.01	0, 100, 0	3.25	0.26	0.16
5/7/2002	0, 100, 0	1.85	0.4	0.35	0, 100, 0	2.1	0.58	0.44	0, 100, 0	2.35	0.64	0.59	0, 100, 0	2	0.55	0.44
5/13/2002	0, 100, 0	2.45	0.66	0.54	0, 100, 0	2	0.83	0.62	0, 100, 0	2.5	0.71	0.61	0, 100, 0	2.45	0.68	0.15
5/20/2002	0, 100, 0	2	0.29	0.18	0, 100, 0	2.4	0.33	0.2	0, 100, 0	3.8	0.78	0.62	0, 100, 0	2.15	0.41	0.22

Appendix C-16. Physical habitat data surrounding fish 821 from May 7, 2002 to September 11, 2002 (12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
5/7/2002	0, 100, 0	1.6	0.81	0.77	0, 100, 0	1.95	0.77	0.56	0, 100, 0	2.65	0.54	0.44	0, 100, 0	2.6	0.79	0.31
5/13/2002	0, 100, 0	1.55	0.66	0.19	0, 100, 0	1.5	0.36	0.22	0, 100, 0	1.45	0.3	0.15	0, 100, 0	1.2	0.21	0.07
5/20/2002	0, 100, 0	1.55	0.37	0.26	0, 100, 0	2.6	0.62	0.42	0, 100, 0	2.05	0.83	0.72	0, 100, 0	2.25	0.44	0.14
5/30/2002	0, 100, 0	2.8	0.09	0.13	0, 100, 0	2.75	0.55	0.37	0, 100, 0	2.85	0.62	0.42	0, 100, 0	2.1	0.22	0.03
7/15/2002*	0, 100, 0	3.5	1.03	0.68	0, 100, 0	3.9	1.04	0.71	0, 100, 0	4.55	0.73	-0.1	0, 100, 0	4.3	0.94	0.49
9/11/2002*	0, 100, 0	1.65	0.46	0.35	0, 100, 0	1.6	0.35	0.32	0, 100, 0	1.75	0.4	0.24	0, 100, 0	2	0.38	0.19

Appendix C-17. Physical habitat data surrounding fish 841 from May 13, 2002 to June 17, 2002 (*12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
5/13/2002	0, 100, 0	2.9	0.79	0.48	0, 100, 0	3.3	0.75	0.72	0, 100, 0	2.9	0.76	0.63	0, 100, 0	2.45	0.8	0.56
5/29/2002*	0, 100, 0	1.9	0.51	0.30	0, 100, 0	2	0.51	0.29	0, 100, 0	2.4	0.46	0.27	0, 100, 0	2.2	0.41	0.28
6/5/2002	0, 100, 0	1.35	0.58	0.45	0, 100, 0	1.5	0.59	0.46	0, 100, 0	1.65	0.58	0.41	0, 100, 0	1.6	0.55	0.44
6/11/2002	0, 100, 0	4.4	0.78	0.5	0, 100, 0	4.5	0.74	0.65	0, 100, 0	4.4	0.83	0.52	0, 100, 0	4	0.8	0.57
6/17/2002	0, 100, 0	6.2	0.9	0.2	0, 100, 0	5.9	0.77	0.44	0, 100, 0	5.95	0.86	0.67	0, 100, 0	6.5	0.78	0.22

Appendix C-18. Physical habitat data surrounding fish 621 (pallid sturgeon) from May 4, 2001 to June 7, 2001.

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
5/4/2001	0, 100, 0	6.2	1.04	0.47	0, 100, 0	5.6	1.19	0.62	0, 100, 0	6.60	1.18	0.62	0, 100, 0	5.7	1.00	0.42
5/6/2001	0, 100, 0	4.3	0.98	0.72	0, 100, 0	5.4	0.85	0.47	0, 100, 0	4.80	0.62	0.46	0, 100, 0	5.2	0.70	0.55
5/9/2001	0, 100, 0	3.35	0.64	0.31	0, 100, 0	3.8	0.69	0.31	0, 100, 0	4.50	0.61	0.45	0, 100, 0	4.8	0.53	0.23
5/14/2001	0, 100, 0	4.3	0.83	0.72	0, 100, 0	4.2	0.82	0.62	0, 100, 0	4.80	0.76	0.53	0, 100, 0	5.1	0.72	0.35
5/15/2001	80, 20, 0	2.3	0.39	0.32	50, 50, 0	3.9	0.84	0.51	0, 100, 0	3.00	1.06	0.6	0, 100, 0	3	0.95	0.47
5/17/2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/22/2001	0, 100, 0	5.3	0.8	0.43	0, 100, 0	2.35	0.81	0.76	0, 100, 0	1.90	0.88	0.58	0, 100, 0	3.25	0.44	0.38
5/24/2001	0, 100, 0	7.1	1.05	0.22	0, 100, 0	5.4	0.96	0.81	0, 100, 0	5.90	0.88	0.61	0, 100, 0	5.8	0.98	0.78
6/1/2001	0, 100, 0	3.7	0.68	0.47	0, 100, 0	2.8	0.88	0.82	0, 100, 0	2.25	0.93	0.92	0, 100, 0	4	0.62	0.07
6/5/2001	0, 100, 0	3.5	0.68	0.48	0, 100, 0	3	0.92	0.85	0, 100, 0	2.50	0.98	0.87	0, 100, 0	4	0.80	0.40
6/7/2001	0, 100, 0	2.9	0.66	0.42	0, 100, 0	2.7	0.79	-0.08	0, 100, 0	1.65	0.79	0.71	0, 100, 0	2.75	0.67	0.48

Appendix C-19. Physical habitat data surrounding fish 721 (pallid sturgeon) from May 28, 2002 to May 29, 2002 (*12-hour survey).

Date	Substrate (%silt, %sand, %gravel) at 2	Depth (ft) at 2	MCV (m/s) at 2	BV (m/s) at 2	Substrate (%silt, %sand, %gravel) at 3	Depth (ft) at 3	MCV (m/s) at 3	BV (m/s) at 3	Substrate (%silt, %sand, %gravel) at 4	Depth (ft) at 4	MCV (m/s) at 4	BV (m/s) at 4	Substrate (%silt, %sand, %gravel) at 5	Depth (ft) at 5	MCV (m/s) at 5	BV (m/s) at 5
5/28/2002*	0, 100, 0	2.4	0.44	0.25	0, 100, 0	1.85	0.56	0.39	0, 100, 0	1.9	0.66	0.53	0, 100, 0	2.1	0.41	0.19
5/28/2002*	0, 100, 0	5.2	1.02	0.72	0, 100, 0	5.3	0.84	0.46	0, 100, 0	4.9	0.89	0.59	0, 100, 0	4.75	0.94	0.51
5/28/2002*	0, 100, 0	8.6	1.15	-	0, 100, 0	7.4	1.17	-	0, 100, 0	7.9	1.15	-	0, 100, 0	8.5	1.00	-
5/29/2002*	0, 100, 0	2.7	0.88	0.65	0, 100, 0	2.9	0.75	-0.02	0, 100, 0	2.55	0.53	0.15	0, 100, 0	2.9	0.53	0.38
5/29/2002*	0, 100, 0	4.3	1.16	0.83	0, 100, 0	5.9	0.94	0.42	0, 100, 0	6.8	1.14	0.02	0, 100, 0	5.45	0.97	0.78
5/29/2002*	0, 100, 0	4.5	1.17	0.46	0, 100, 0	5.45	1.18	0.32	0, 100, 0	5.15	1.01	0.47	0, 100, 0	5.5	0.91	0.68
5/29/2002*	0, 100, 0	3	1.11	0.85	0, 100, 0	3.5	0.94	0.43	0, 100, 0	4.8	0.63	0.17	0, 100, 0	3.7	0.76	0.59